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ENGINEERING:

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An Illustrated Weekly Journal.

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VOL. CXIII.—No. 2931.] *LONDON: FRIDAY, MARCH 3, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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See Advertisement, pages 27 and 67, last week.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 3179

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Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28, 1921.

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Boilers.
See page 17, Feb. 24. 9047

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RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
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Diesel Engines, Six Cylinder,
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See Advertisement page 77.

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FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, } ROW'S PATENTS.
CONDENSERS, AIR HEATERS,
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
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MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—122, BUTE ST.
BIRMINGHAM WAREHOUSE—MILK STREET, SHEEPSHOUSE STREET.
See Advertisement, page 26. 9952

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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

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See Advertisement page 60, Feb. 24. 9402

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Duckham's Patent Suspended
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and Principal Provincial Cities.

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MOTHERWELL, SCOTLAND. 9727
See half-page Advertisement page 42, Feb. 17.

See Advt. Page 88 Feb. 24.
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Founded 1854 by SIR WILLIAM FAIRBAIRN.
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Inst. C.E., I. Mech. E., B.Sc., and all Engineering Examinations.—Mr. G. F. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 566

Inst. C.E. Exams.—Successes as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "A" embraces 25 years' professional experience. Address, 7454, Offices of ENGINEERING.

Penningtons, University TUTORS, 284, Oxford Road, Manchester. Estab. 1876. Postal courses for all Engineering Exams. Enrol now for I.C.E. and I.M.E. Courses. 100 per cent. passes last Exams. 9750

TENDERS.

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply of :—
WASHERS, Steel, Spring.

Forms of Tender may be obtained from the Director-General, India Store Department, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than TWO o'clock p.m. on Friday, the 17th March, 1922.
T. RYAN, Director-General. T 587

SWANSEA HARBOUR TRUST.

The Swansea Harbour Trustees invite

Tenders for the Repair of certain FERRO-CONCRETE QUAYS in their King's Dock, by means of the Cement Gun. The quays may be inspected, and further particulars of the nature of the repairs to be executed may be obtained, on application to the Trustees' Engineer, Mr. A. O. SCHENK, M.I.C.E., Harbour Offices, Swansea.

Tenders, marked "Repairs to Quays," should be delivered to the undersigned not later than Ten a.m. on Friday, the 24th March, 1922.

The Trustees do not bind themselves to accept the lowest or any Tender.

TALFOURD STRICK, Clerk.

Harbour Offices, Swansea.
25th February, 1922. T 571

GREAT SOUTHERN & WESTERN RAILWAY (IRELAND).
CONTRACTS 1922.

The Directors of the Great Southern and Western Railway Company are prepared to receive

Tenders for the Supply of the undermentioned STORES for Three Months commencing 1st April, 1922.

	No. of Form.		No. of Form.
Acid, Sulphuric ...	32	Glass and China Sundries	27B
Asbestos Sheeting, etc.	40	Hardware (Sundry)	17
Baskets	10	India Rubber Goods	24
Bolts, Nuts and Rivets	15	Implements, Sundry	21
Brooms and Brushes	13	Iron Tubes and Fittings	29
Brass Fittings for Carriages... ...	18	Leather	12
Do. do. for Water	26A	Locks and Keys ...	9
Do. do. for Gas ...	26B	Mats, Fibre	10
Canvas and Sacks ...	6	Nails	31
Castings, Mall. Iron	11	Packings	40
Clothing, Oil... ...	22	Plumbago	41
Do. L.B. proofed ...	22	Railway Fastenings (Iron)	16
Coach Screws and Washers	15	Do. (Steel)... ...	16A
Corks	39	Rain Water Pipes and Gutters	25
Crucibles	41	Ropes, Twine, & Flax	4
Drysalteries	3	Soaps	30
Emery and Glass Cloth, etc.	28	Sponge Cloths ...	5
Files and Tool Steel	20	Signal Wire Pulleys	11
Fire Bricks and Clay	33	Screws and Split Pins	14
Foundry Requisites	42	Tin Plates	22
Galvanized Sheets, Buckets, etc. ...	23	Waste	8A
Grates, Stoves and Fenders	24	Waterproof Clothing	22
Grindstones	28	Wicks	8
Glass, Sheet, and Plate	27A	Wire, Fence and Signal	30A
		Wirework	30B

Forms of Tender can be obtained on PAYMENT of 1s. each from the STORES SUPERINTENDENT, GENERAL STORES DEPARTMENT, G.S. & W.R., INCHICORE, DUBLIN. Applications for forms by Post must be accompanied by Postal Order. Stamps cannot be accepted. All enquiries for information should be also directed to the Stores Superintendent.

Patterns may be inspected at the General Stores Department on and after the 3rd inst., between the hours of Ten a.m. and Four p.m. (except on Saturdays).

Tenders must be enclosed in the special envelope supplied for the purpose with each schedule, and must be posted so as to be with the undersigned before Ten a.m. on Wednesday, 15th March, 1922.

The Directors will not consider any Tender unless it is furnished on the Company's Form, and do not bind themselves to accept the lowest or any Tender.

By Order,
ROBERT CRAWFORD, Secretary.
Kingsbridge Terminus, Dublin,
March, 1922. T 602

TO FIRMS WANTING CONTRACTS.

Quotations are Required, for manufacture, in batches, of 250, on repetition lines, of lightly constructed brass hand-operated air pumps for low pressures, 2 in. bore by 15 in. stroke, with solid drawn tubular barrel, single disc valve and special two-way cock. The product is simple and easily made in any plain machine shop. Prices should be as if for a single lot of 250 although expected to be repeated from time to time.

The advertiser does not bind himself to accept the lowest or any quotation. Drawings of complete article showing all production data will be sent upon payment of fee of 12s. 6d., which will not be returned under any circumstances, to Mr. H. GEORGE HARLEY, Consulting and General Engineer, Grand Avenue, Camberley. T 551

THE BURMA RAILWAYS COMPANY, LTD.

The Board of Directors of the Burma Railways Company, Ltd., are prepared to receive

Tenders for the Supply of :—
200 PICK AXES.
4000 PLATELAYERS' PICKS, and
6000 PHOWRAHS.

For each copy of the Specification a fee of 10s. will be charged, which fee is not returnable. Tenders, enclosed in sealed envelopes, endorsed "Tender for Picks and Phowrahs," must be delivered at the Company's Offices not later than Twelve Noon on Monday, 13th March, 1922. The Directors do not bind themselves to accept any or the lowest Tender and reserve the right to divide the order.

By Order of the Board,
F. C. FRANKS, Secretary.

199, Gresham House,
Old Broad Street,
London, E.C. 2.
3rd March, 1922. T 614

SWANSEA HARBOUR TRUST.

The Trustees invite

Tenders for the Supply and DELIVERY of the following :—
900 NEW CREOSOTED SLEEPERS, 9 ft. by 10 in. by 5 in.

Approximately 2300 cub. ft. 12 in. by 6 in. PITCH PINE CROSSING TIMBERS, in length varying from 9 ft. to 26 ft. A schedule of length will be supplied.

About 47 tons CAST IRON RAILWAY CHAIRS, approximately 44½ lb. each.

About 5 tons of 7½ in. by ⅝ in. and about 5 tons of 8½ in. by ⅝ in. FANG BOLTS with 3 in. Triangular Shoes.

Further particulars may be obtained of the Trustees' Engineer, Mr. A. O. SCHENK, M.I.C.E., Harbour Offices, Swansea.

Tenders, sealed and marked "Railway Material," to be delivered to the undersigned on or before 17th March, 1922.

The Trustees do not bind themselves to accept the lowest or any Tender.

TALFOURD STRICK, Clerk.

Harbour Offices, Swansea.
March 1st, 1922. T 623

CITY OF LEICESTER.

STEAM BOILERS, ETC., FOR ABBEY SEWAGE PUMPING STATION.

The Sewage Works and Farms Committee invite

Tenders for :—
(1) LANCASHIRE BOILERS.
(2) MECHANICAL STOKERS and COAL CONVEYING PLANT.
(3) SETTING OF THE BOILERS.

Forms of Tender, etc., may be obtained at my office on payment of the sum of £2, which will be returned on the receipt of a bona fide Tender. Cheques, etc., to be made payable to the Corporation of Leicester.

Applications should state section desired.

Sealed Tenders on the forms supplied, addressed to the "Chairman of the Sewage Works and Farms Committee, Town Hall, Leicester," must be delivered not later than 20th March, 1922, and endorsed "Tender for Boilers, etc."

The Committee do not bind themselves to accept the lowest or any Tender.

H. GEORGE MAWBEY, M.Inst.C.E., City Engineer and Surveyor.

Town Hall, Leicester,
21st February, 1922. T 535

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to :—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place,
Strand,
London, W.C. 2.

SPECIFICATION No. 200. 22,000 volt 3-core CABLE and ACCESSORIES.

CHARGE :—
£2 2s. for the first two copies of Specification and 10s. 6d. per copy thereafter. These charges will be returned on receipt of a *bona fide* Tender.

PRELIMINARY DEPOSIT :—
A preliminary deposit of 1 per cent. (not exceeding one hundred pounds—£100) is to be lodged with Tender.

The Specification may be inspected at the above mentioned Office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne, not later than 25th April, 1922.

R. LIDDELOW, Secretary.
State Electricity Commission of Victoria,
673, Bourke Street,
Melbourne,
Victoria,
AUSTRALIA. T 525

MIDLAND GREAT WESTERN RAILWAY OF IRELAND COMPANY.

PLATE GIRDERS AND STEEL TROUGH DECKING.

The Directors of the above Company are prepared to receive

Tenders for the Supply and DELIVERY of TWO PLATE GIRDERS and STEEL TROUGH DECKING for Underline River Bridge.

Specification, giving all particulars, and Drawing can be had on application to the undersigned.

Tenders, sealed and endorsed "Tender for Girders," must be forwarded addressed to the Chairman, Midland Great Western Railway of Ireland Company, Broadstone Terminus, Dublin, so as to reach him not later than Monday, 20th March, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

PERCY A. HAY, Secretary.

Broadstone Terminus, Dublin.
28th February, 1922. T 606

MIDLAND GREAT WESTERN RAILWAY OF IRELAND.

GAS ENGINE FOR SALE.

The Directors of the above Company are prepared to receive

Tenders for the Sale of One 75 maximum B.HP. National SUCTION GAS ENGINE, together with Generator, Charging Hopper, Fuel Container, Scrubber, &c., complete.

Makers—The National Gas Engine Company.

The engine was supplied new to this Company in the latter half of 1917, and its condition is equal to new.

Purchaser to remove engine at his own expense, but the Company will provide crane to facilitate removal at Purchaser's risk.

The engine can be inspected and full particulars obtained on application to Chief Engineer's Office, Broadstone Station, Dublin.

Tenders to be forwarded addressed to the Chairman, Broadstone Station, Dublin, so as to reach him not later than Monday, 20th March, 1922.

The Directors do not bind themselves to accept the highest or any Tender.

PERCY A. HAY, Secretary.

Broadstone Station, Dublin.
28th February, 1922. T 630

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely :—

No.		Fee for Specification.
1.	Cast Iron Pot Sleepers	20/-
2.	Tie Bars, Gibs and Cotters	10/-
3.	Steel Rails and Fishplates	20/-
4.	Steel Fishbolts, Spikes, &c.	10/-
5.	Tyre Retaining Ring Bolts and Nuts	5/-
6.	Carriage Door Handles, Hinges, &c.	10/-
7.	Cranked Fishplates	5/-
8.	Railway Tickets	10/-

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Cast Iron Pot Sleepers," or as the case may be, not later than Eleven o'clock a.m. on Tuesday, the 14th March, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE, Secretary.

Company's Offices,
48, Copthall Avenue, London, E.C. 2.
1st March, 1922. T 629

APPOINTMENTS OPEN.

Wanted for India, an Under MANAGER accustomed to running a modern Cement Works on the wet process. Salary up to 1000 Rupees per month according to experience. Healthy situation. Free unfurnished quarters, and passage out and home. Applicant must have held similar situation in England.—State age, whether single, and full particulars to MAXTED & KNOTT, LTD., Consulting and Cement Engineers, Burnett Avenue, Hull. T 620

Engineers' Tool Merchants, wishing to extend, have VACANCY for GENTLEMAN with thorough knowledge of trade, and able to influence orders. Preferably one who is willing to take up shares.—Apply, by letter only (in confidence), STOCKTON & BUNN, LTD., 11, Queen Victoria Street, E.C. T 618

Civil Engineer Required Immediately for the position of Agent-in-Charge of the works for constructing large Masonary Dams in North Brazil. Applicants should have held a similar position previously and should speak Portuguese.—Address, T 59r, Offices of ENGINEERING.

Civil Engineer Required by the GOVERNMENT OF ZANZIBAR for one tour of 20 to 30 months' service as an Assistant Engineer on Water Supply. Salary £700 per annum. Free quarters and first-class passages.

Candidates, preferably single, must be A.M.Inst. C.E. or possess similar professional qualifications, and must have had good practical experience on Water Works. The person appointed will be required to lay out and supervise the construction of water works, pipeline and other details.

Apply at once in writing to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1., quoting M/Zanzibar 11371. T 613

Wanted, Engineer thoroughly experienced in Aerial Ropeways, to take charge of Drawing Office. Also a LEADING DRAUGHTSMAN required. State full particulars, experience, salary, etc.—Address, T 563, Offices of ENGINEERING.

Electrical Engineer Required, with good knowledge and experience in the design and construction of electrical battery vehicles, to carry out experimental work and develop same.—Address, stating age, qualifications and salary required, T 584, Offices of ENGINEERING.

INDIAN SERVICE OF ENGINEERS AND ENGINEERING ESTABLISHMENT OF INDIAN STATE RAILWAYS.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL will in 1922

Appoint 11 Assistant EXECUTIVE ENGINEERS for these Services if so many suitable candidates present themselves.

Every candidate must be a British subject, or a ruler or subject of any State in India in respect of whom the Governor-General of India in Council has made a declaration that he is to be considered eligible.

The appointments for Europeans will be reserved for candidates who have served in His Majesty's Forces during the War for at least one year, or who have been prevented on adequate grounds from so serving. European candidates must have been born on or after 2nd August, 1896, and on or before 1st August, 1900.

Indian candidates must have attained the age of 21 and not attained the age of 24 years on the 1st July, 1922, except that in the case of an Indian who has rendered service of the nature defined in the preceding paragraph, the same maximum age limit as for Europeans will apply. Subject to this exception, the maximum age limits of 24 years for Indian candidates will be maintained for the next year and will be reduced to 23 years in 1924.

Every candidate must either (1) have obtained one of certain recognised University degrees or other distinctions in Engineering, or (2) have passed Sections A. and B. of the Associate Membership Examination of the Institution of Civil Engineers, or been exempted by the Institution from such examination, or (3) produce the required evidence that he is otherwise eligible under the Regulations.

Applications from candidates must reach the India Office not later than 1st April. Printed forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, PUBLIC WORKS DEPARTMENT, India Office, Whitehall, London, S.W. 1.

INDIA OFFICE, LONDON,
19th December, 1921. T 73

Required at Once a Good PRACTICAL MAN capable of supervising running repairs and maintenance work on Railway Wagons. First hand knowledge of Wagon construction and repair work essential.—Apply, giving full information as to experience, wages required, age, etc., to WAGON, c/o 19, Corporation St., Birmingham. T 625

Capable Draughtsman REQUIRED. Used to design of enclosed Refrigerating Machines.—Address, T 615, Offices of ENGINEERING.

Egypt.—Wanted, a Working ERECTOR, with experience of controlling Arab or Eastern Labour, to erect small High Pressure Pumping Station, Semi-Diesel Engine, and Pipeline. — Reply, SINAI, care of GILBERT GILKES & Co., Ltd., Kendal. T 605

India.—Required Immediately, experienced WAGON SHOP FOREMAN, unmarried, five years engagement, free passage out and home. Good opportunity for thoroughly capable man.—Address, giving experience and copies of testimonials, T 528, Offices of ENGINEERING.

SITUATIONS WANTED.

Works Manager, Scotchman, 14 years in charge of the Constructional, Foundry, Smith's and Machine Shops of the largest Building Firm in India, can control labour, speaks Hindustani, Bengali, WISHES similar APPOINTMENT in the East. Willing to consider anything reasonable with prospects. Good references.—Address, T 589, Offices of ENGINEERING.

Buying Engineer. — The Manager of a large Engineering Works Purchasing Department, who has an exceptionally wide knowledge of the Markets of the Country, DESIRES to Negotiate NEW APPOINTMENT. —Write, Z. M. 615, care of DEACON'S, Leadenhall Street, E.C. 3. T 587

Engineer, B.Sc. (Glasgow), M.A. (Cantab.), M.I.Mech.E., DESIRES SITUATION, preferably in charge of sales, organisation of engineering works. Has had considerable experience in this work, including designing, estimating & travelling.—T 396, Offices of ENGINEERING.

Engineer 35, A.M.I.M.E., M.I.A.E. many years experience Works and Business Management and with complete commercial experience including Sales Organisation, Experienced Designer, and with extensive knowledge of Works Accountancy, shortly relinquishing Managing Directorship, seeks Responsible Managerial Appointment. Would entertain home, continental, or foreign representation.—T 445, Offices of ENGINEERING.

Master Mechanic or Maintenance Engineer, age 42, 26 years' exp. Positions held :—Tool-room Foreman, M/c Shop Foreman, Charge Engineer Printing Works, Charge Engineer Brewery. DESIRES SITUATION home or abroad.—Address, T 586, Offices of ENGINEERING.

Mechanical Engineer (24), holding Industrial Bursary, Diploma Tech. Coll., six years shops and D.O., with extensive experience in Steam Plants, DESIRES Responsible POST at a nominal salary of £50 per annum.—OSBORNE, 136, Errol St., Aigburth, Liverpool. T 604

THE THICKNESS AND RESISTANCE OF OIL FILMS IN HIGH SPEED BEARINGS.

By GERALD STONEY, D.Sc., F.R.S., R. O. BOSWALL, B.Sc.(Eng.)Lond., and J. MASSEY, B.Sc.Tech.

ALTHOUGH the problem of efficient lubrication has been made the subject of considerable investigation during the course of the last few years, it is a noticeable fact that while the theoretical side of the work has received extensive development, notably from Osborne Reynolds, Sommerfield, Michell and Martin, the experimental side, represented by the researches of Tower, Stribeck and Lasche amongst others, has been entirely confined to measurements of pressure distribution, temperature changes, and shear or frictional resistance, no direct attempt having apparently been made to determine experimentally the actual thickness of an oil film or to discover in what way this thickness changes with variations in load, rubbing speed and viscosity.

With the express object of filling this gap in what must of necessity be regarded as a subject of increasing practical importance, owing to the recent rapid developments in turbine construction, an experimental investigation of an essentially preliminary character has been carried out during the past year at the College of Technology, Manchester.

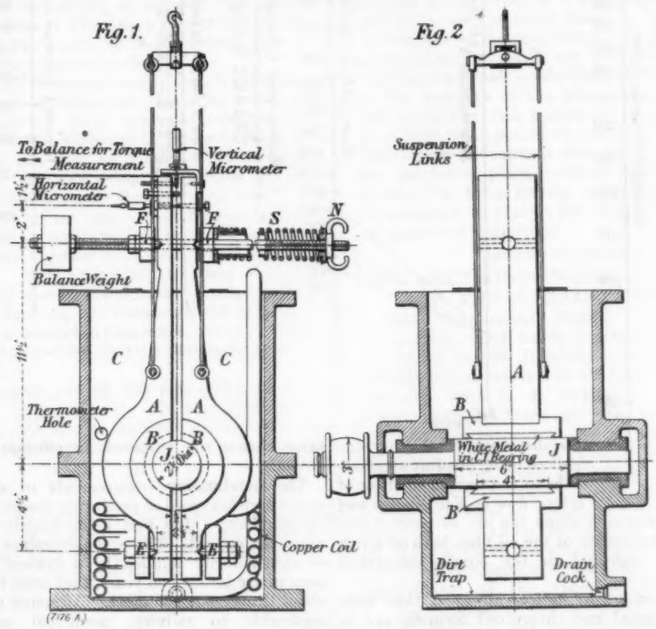
The apparatus employed was specially designed for the purpose, and the measurements of oil film thickness and shear or frictional resistance that have been obtained from it up to the present appear to be of sufficient interest to justify their publication.

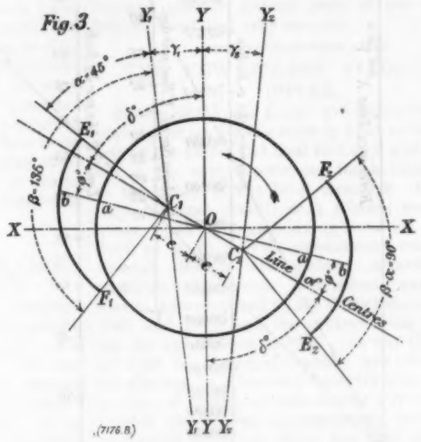
The apparatus referred to is shown in Figs. 1 and 2. It consists essentially of a cast-iron casing C, provided with two gunmetal bearings in which runs the mild steel journal J, speeds of from 2,500 r.p.m. to 6,000 r.p.m. being obtainable by means of a belt drive from a small electric motor. The central portion of the journal, 2·5 in. in diameter, is embraced by two opposing symmetrically-shaped white metalled bearings B B, each 4 in. long and carefully scraped to fit the journal as exactly as possible over an arc of contact of 90 deg.

These bearings are secured to two arms A A, which are held together by means of two independent links provided with knife-edge attachments. The lower pair of these knife-edges E E, are maintained at a fixed distance apart, while the upper pair F F are relatively movable, being controlled by the calibrated spring S, which can be compressed by the wing nut N so that any desired pressure can be exerted by the bearings on the journal, the lower knife-edges acting as a fulcrum.

The weight of the arms and their various fittings is counterbalanced by means of a four-rod suspension to relieve the journal of all vertical pressure, the position of these points of suspension on the arms being chosen so as to maintain just sufficient rotational stability about the journal axis to keep the arms in their normal vertical position, while not interfering with possible displacements of the arms relative to one another.

The casing is filled with oil to a level of about 3 in. above the top of the journal, a copper water circulation coil being inserted in the lower half of the casing to facilitate temperature regulation.





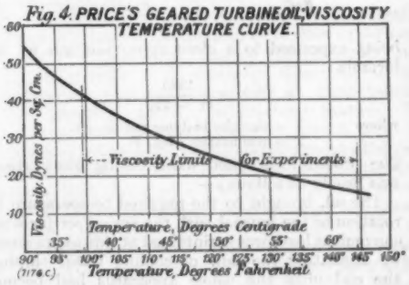
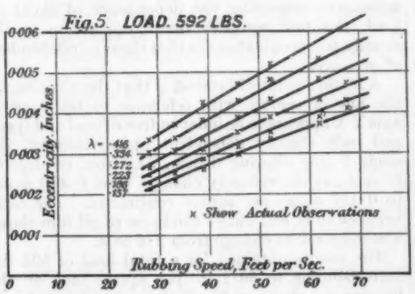
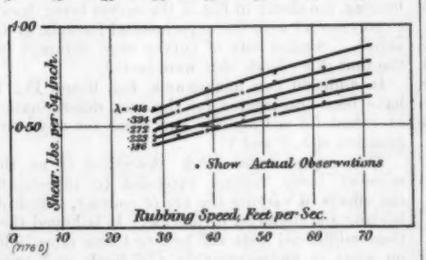


Fig. 4. PRICE'S GEARED TURBINE OIL. VISCOSITY TEMPERATURE CURVE.
Viscosity Limits for Experiments
Viscosity, Dynes per Sq. Cm.
Temperature, Degrees Centigrade
Temperature, Degrees Fahrenheit
(7176 C.)





The method of operation of the apparatus is briefly as follows:—

Referring to Fig. 3, and assuming that the two white metalled bearings E_1, F_1, and E_2, F_2, are initially in contact with the journal and under the influence of pressure due to the spring, a rotation of the journal in the direction indicated will result in a wedge-shaped film of oil being introduced between each brass and the journal, the thickness of this film being dependent upon the pressure, rubbing speed and viscosity of the oil. The formation of this film will necessarily be accompanied by small displacements of the arms holding the brasses, the only restraint to the relative motion being that supplied by the spring. The motion of each arm may, in fact, be considered as combined of a translation parallel to the vertical axis Y Y and an angular rotation through an angle γ about the lower knife-edges.

To measure these relative displacements, shown much enlarged in the figure, two micrometers, one vertical and the other horizontal are fitted at the end of the arms, the measurements thus obtained enabling the actual displacement of the brasses relative to the journal and the thickness of the film to be calculated.

The shear or frictional resistance was determined by the measurement of the horizontal force required at the end of the arms to counteract the turning effect about the journal axis and maintain the arms in their normal vertical position.

It will be seen that if ϕ represents the angle between any radius O a b and the lines joining the centre of the journal O to the displaced centres C_1 and C_2 of the brasses, the thickness of the film at this point will be given by

$$t = e \cos \phi ,$$

where e is the eccentricity or distance between the centre of the journal and the centre of the brass, also, if δ is the angle between the line of centres and the vertical axis Y Y, the thickness of the oil film at inlet and outlet will be given by

$$t_1 = e \cos (\alpha - \delta)$$
$$t_0 = e \cos (\beta - \delta)$$

The values for e and δ can be calculated from the micrometer measurements and the known dimensions of the apparatus. The oil used throughout the tests was Price's geared turbine oil, having a specific gravity of 0·88 at 60 deg. F. The viscosity was determined in the first instance by use of a Michell viscometer having a constant 14·4, the results obtained thereby being checked by an additional series of observations made with a standard Redwood instrument, a calibration formula being applied to reduce times of outflow to absolute units of viscosity—*i.e.*, dynes per square centimetre, as given directly by the Michell instrument. The agreement between the two methods was very satisfactory, and the viscosity temperature curve is shown in Fig. 4, the relationship between the two variables over the temperature range used

THE THICKNESS AND RESISTANCE OF OIL FILMS IN HIGH SPEED BEARINGS.

Fig. 6. NOMOGRAM FOR ECCENTRICITY.

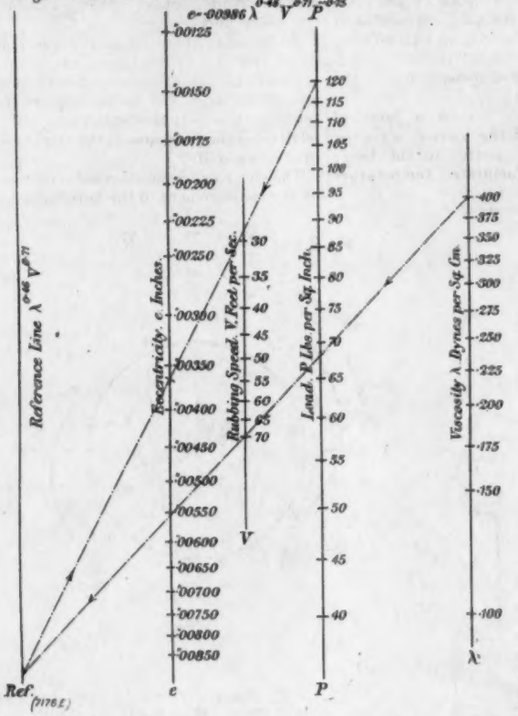
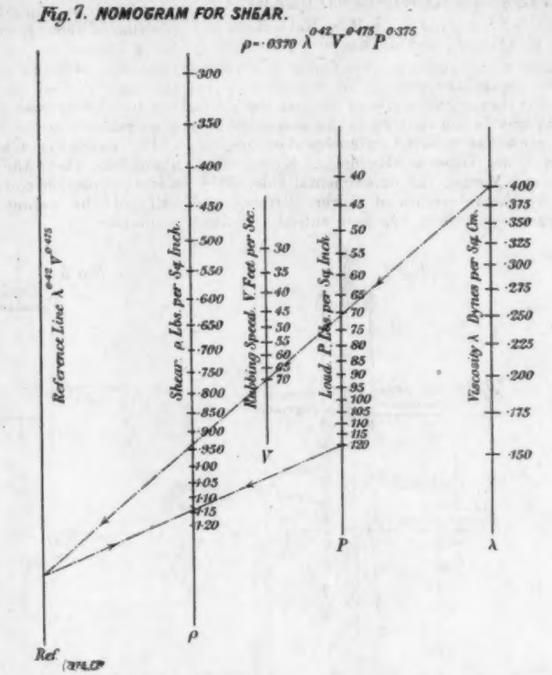


Fig. 7. NOMOGRAM FOR SHEAR.



being expressed to a close approximation by the formula :

$$\lambda = \frac{1980}{(T - 32)^2}$$

where λ = viscosity in dynes per sq. cm.
T = temperature, deg. F.

The procedure adopted when taking observations was briefly as follows :—

The oil, brought to the required temperature by rotation of the journal with the spring set for some convenient load, was maintained at this temperature by regulating the flow of cooling water through the coil until the whole apparatus had become correspondingly warmed up. The journal was then stopped and the spring correctly adjusted to give the desired test load on the brasses. Initial zero readings having been taken, the journal was re-started and measurements made for a series of gradually-increased speeds, at the end of which the journal was stopped and zero readings again taken as a check.

Analysis of the complete set of results indicates that within the limits of the experiments which were from 39·5 lb. to 117·5 lb. per square inch for load, 28 ft. to 67 ft. per second for rubbing speed, and 0·416 C.G.S. to 0·157 C.G.S. units for viscosity, the eccentricity e and the intensity of shear ρ, or its equivalent μ P, may be expressed to a very close degree of approximation by the formulæ :

$$e = 0{\cdot}00980 \frac{\lambda^{0{\cdot}46}\, V^{0{\cdot}71}}{P^{0{\cdot}75}} \text{ inches}$$

$$\rho = 0{\cdot}0370\, \lambda^{0{\cdot}42}\, V^{0{\cdot}475}\, P^{0{\cdot}375} \text{ lbs. per sq. inch.}$$

where λ is the viscosity in dynes per sq. cm.
V is the rubbing speed in feet per sec.
P is the intensity of pressure on the brasses in lbs. per square inch.

The intensities of pressure and shear are reckoned on the full projected area of the journal, *i.e.*, 10 sq. in. In putting forward these formulæ we reserve until more complete data are available the devising of rational formulæ which shall be applicable to all similar bearings, and they are put forward merely as a compact method of recording the actual observations. These formulæ do not compare unfavourably with the purely theoretical formulæ

$$e = c \left(\frac{\lambda V}{P}\right)^{0{\cdot}6}$$

$$\rho = k\, (\lambda\, P\, V)^{0{\cdot}5}$$

the discrepancy affecting the indices being possibly attributable to the combined effect of lateral flow or side leakage and variation of viscosity along the arc of contact due to rise of temperature of the oil film, both of which factors are neglected in the simple theoretical treatment.

It is important to notice, however, that both the experimental and theoretical formulæ are in agreement respecting the dependence of shear on load, this fact being in direct opposition to the usually accepted statement that shear is independent of pressure.

A further point of interest is that the position for the line of centres with reference to the vertical axis Y Y appears to be independent of load and speed and only slightly dependent upon viscosity, the angle δ only altering 3 deg., *i.e.*, from 66 deg. to 63 deg., as the viscosity changes from 0·416 dynes to 0·157 dynes per square centimetre. The ratio between inlet and outlet thickness of oil film shows a corresponding change from 2·6 to 3.

The results obtained for a total load of 592 lb., corresponding to 59·2 lb. per square inch on the bearing, are shown in Fig. 5, the curves being drawn to correspond with the experimental formulæ given above. Similar sets of curves were obtained for the four other loads that were tested.

In addition two nomograms, Fig. 6 and Fig. 7, have been constructed for the easy determination of values for eccentricity and shear for any combination of λ, P and V.

The experimental work described is at the moment being further extended to investigate the effects of varying the arc of contact, length of bearing and diameter of journal. It is hoped that these additional tests will help to throw more light on what is unquestionably a difficult and complicated subject.

PLAN FILING FOR RAILWAY AND MUNICIPAL ENGINEERS.

By J. TAYLOR THOMPSON, Assoc.M.Inst.C.E.

IN a large office where the number of plans stored is to be counted in hundreds or perhaps thousands, the time wasted and annoyance caused by an inefficient filing system or by absence of system is so well known to those affected that a detailed condemnation is superfluous. For the same reason the value of an efficient system is obvious.

The outstanding requirements of an efficient system are (*a*) speed in producing the plan required, (*b*) simplicity ; the first being largely dependent upon the second. These requirements have been so satisfactorily fulfilled by a system which has been in use for sixteen years, that some information about it may be of interest. Although particularly applicable to railway, municipal and county engineers, it is suitable for any plan store containing plans of various classes of work and extending over a large area.

The system is based upon two main divisions ; the first applying to the area or railway covered, and the second to the subjects of the plans. For simplicity of description the application of the system to the plans of a railway company will be taken. In the first place the railway system is divided into sections, these being arranged so that the number of plans in each will be approximately the same. That is to say, in thickly populated areas where bridges, stations and railway works generally are more numerous, the section will be smaller than in open country where these works are not so necessary. This difference in size of sections is not essential to the working of the filing system, but it is advisable, for speed of reference, to balance the sections in this way. These sections are then numbered or indicated by a combination of a number and a letter, such as 1A, 1B, 1C, 1D, . . . , 2A, 2B, 2C, 2D, &c. Every plan relating to work in section 1A will bear that mark, and similarly with every other section, no matter what the subject of the plan may be. This is the primary division and divides the whole of the plans into a number of sections corresponding to the number of sections into which the railway has been divided.

The second division relates to the subjects of the plans. Bridges must be kept separate from surveys, and these from cross-sections, and so on. It is found that in the case of plans filed in a railway engineer's plan store the subjects dealt with can be conveniently divided into nine divisions, and the following has been found suitable :—

1. Footbridges, subways, level crossings.
2. Bridges, tunnels, viaducts, arches.
3. Stations, buildings, foundations, pile-driving machinery, cranes, lifts, engine sheds.
4. Docks, river walls, coal staiths, soundings, buoys, and dolphins.

5. Surveys, depots, loading docks, cattle docks.

6. Sites, land plans, including Parliamentary sheets, maps and plans of routes, position of cables, live rails, distances.

7. Permanent way details, including third rail, signal bridges and turntables, retaining walls, borings, gas works, fire pits, culverts and drains, reservoirs, water tanks.

8. Schemes of all kinds.

9. Longitudinal and cross-sections.

This list can, of course, be extended to include architects and signalling plans and, if necessary, any other plans which it may be required to include in the filing scheme. If this division be adopted every bridge plan will bear, in addition to the mark indicating its section of railway, the number 2; thus the plan of a bridge in section 3B would, thus far, bear the marks 3B/2, and a land plan in the section 2A would be marked 2A/6.

It is still necessary to distinguish between plans in the same division, and this is done very simply by numbering them consecutively as received. If, for instance, there are 20 bridge plans in section 3B, they are filed as 3B/2/1, 3B/2/2, 3B/2/3 to 3B/2/20; 3B indicating the section of railway, 2 the subject division (bridges, &c.), and 1, 2 or 3, the number of the plan in that division. Should an additional bridge be built in section 3B, the plans of this, if filed together as one roll, would be numbered 3B/2/21. This completes the filing of the plans, and every plan included in the system has therefore three references, one indicating the section of the railway to which the plan refers, the second denoting the subject division, and the third its number in that division.

The making-up of the plan book is a simple matter, requiring very little explanation. For example, the bridges (subject division 2) in section 3B are shown as follows:—

$$\frac{3B}{2}$$

1. Bridge over main road near————Station.
2. Occupation bridge between————and———— C.R. 2B/2/5. Details of parapet walls on———— to————contract bridges.
3. ————

&c.

Particulars which assist in identifying the bridge, such as bridge number, mileage, and name of bridge, should be added, if available.

In a case where there is doubt as to which subject division is applicable the plan is filed under one subject and a cross reference given under any other subject which might possibly be considered applicable. The same method is adopted when a plan shows work partly in one section and partly in another; it is filed in one section and a cross-reference given in the other. Thus in the example given above the drawing giving details of parapet walls on the bridges of a certain contract covers sections 2B and 3B, and the plan has been filed under 2B and a cross reference given under 3B. It is almost unnecessary to add that sufficient space should be left at the end of each division to allow for additional plans.

The method of storing the plans has not yet been referred to, and it is possible that difference of opinion will be met with here. There are advantages in filing plans flat in drawers and also advantages in adopting the rolled plan as the standard, but the filing system described applies equally well to both methods. The writer is of the opinion that when a considerable percentage of the plans to be dealt with are too long to be filed flat, it is advisable to adopt the rolled method for all and store them in pigeon holes. A combination of drawers and pigeon holes is not advisable unless under exceptional conditions.

When pigeon holes are used these should be about 3½ in. by 3½ in., and long enough, of course, to take the largest plan. A cupboard, 7 ft. by 4 ft. provides 234 pigeon holes of this size. The cupboard is clearly marked with the section divisions of the plans it contains, and the commencement of each section division indicated in the cupboard. A framed map of the railway system, with the various sections shown by different colours and numbered, is displayed in a convenient position in the plan room, and also a list of the subject divisions.

When a plan is obtained from the store some record is required to show the name of the person obtaining the plan, and the date. For this purpose a receipt book with counterfoils is used, and for every plan obtained a receipt must be signed giving the date, name of the person requiring the plan, plan reference number, and description of plan. The signature must be that of the actual person obtaining the plan, whether messenger, office boy, or the assistant who requires the plan. The receipt is placed in the pigeon hole from which the plan is obtained, and on any subsequent inquiry for the plan full particulars are thus at once available. When the plan is returned and placed in its pigeon hole the receipt is destroyed. The counterfoil in the receipt book is used in the event of a plan being out of store without a receipt being found in its pigeon hole. A reference to the counterfoils will give particulars of occasions on which the plan has been in use, and inquiries made on the basis of these should lead to the recovery of the plan. Cases of this kind will be of very rare occurrence in a well managed plan store, but a periodical stocktaking is advisable. The writer is confident that no matter how large the number of plans involved or how varied their nature, the filing system described will be found in operation to possess the efficiency requirements of speed and simplicity.

THE METEOROLOGICAL LABORATORY OF THE CANADIAN SURVEY.

THE Metrological Section of the Survey's Laboratory, which has to supply standard measures of length to the Dominion land surveyors, was established at Ottawa in 1913 and was, after consultation with C. E. Guillaume, of the Bureau International at Sèvres, provided with a comparator base of the permanent bench mark type, 32 m. in length. Most of the equipment has come from the Société Genevoise d'Instruments de Physique, and has been installed in the large test room of a one-storey building which embodies several novel features. To whom the design is due is not stated in Bulletin 44 of the Topographical Survey Branch on "Standardisation of Measures of Length at the Laboratory of the Dominion Lands Surveys."

The building is 150 ft. long by 10½ ft. wide and 12 ft. high; it has only one entrance through a vestibule at the one end, which is closed by a double door of the refrigerator type (two doors 4 ft. apart), and has no windows. All work is done by the light of tungsten lamps filled with nitrogen.

The walls are 4 ft. thick and composed, reckoning from outside, of five thicknesses of brick, an air space of 1 in., 1 in. of wood sheeting, tar paper, 18 in. of shavings, tar paper, 1 in. of wood sheeting, an air space of 4 in., and finally double wood sheeting. The flat roof is separated by a wide air space from 2 ft. of wood shavings resting on the ceiling. Under the floor are 12 in. of shavings and then cinders, on the solid rock. Ventilation is maintained (by two fans suspended from the ceiling) through two outlets extending through the roof, and two intakes, one at each end of the room near the floor; the intakes can be closed by dampers, and the air entering passes over heaters. Electric radiators are provided along both sides. The Johnson heat regulator and thermostat kept the temperature in one January week of 1917, of which curves are given, steady between 16 deg. and 17 deg. C.

The comparator base consists of a continuous block of concrete, 32 m. long, resting on the solid rock; nine concrete pillars, 4 m. apart, and one additional pier project from the block through the floor, from which they are insulated. The piers are in pairs, the one pier bearing the bench mark, the other supporting the rail track. There are no water troughs or similar apparatus. Systematic measurements taken during the two years 1915 and 1916 show that the length of the concrete block fluctuated very slightly according to the atmospheric temperature, lagging behind that temperature by about six weeks; the expansion is not the same in all the sections between two consecutive piers, and over one section there may indeed be contraction when expansion takes place in the others; but the fluctuations were very small and never exceeded 19 μ or 1 in 1,600,000 per day.

When the 1 m. comparator, which is mounted at the zero end of the 32-m. base, is to be used, the parts are put in position, and the ventilation is then stopped for 24 hours, after which time the two standards to be compared will be of the same temperature. The chief standards are a 1-m. bar and a 4-m. bar, both of invar. In the comparator, the 1-m. bar (which travels to other institutions for comparisons) is suspended by hangers from an invar tube; the 4-m. bar runs on wheels on a carriage; any slight curvature in the 4-m. bar is checked by means of two collimators, one fixed to the carriage, the other to the pier.

Tapes to be measured are suspended on hangers from the ceiling and are lowered when required. The various interesting appliances are illustrated in the Bulletin mentioned. The Laboratory is much in demand already, though part of the equipment has been installed very recently.

THE NEW STREET VIADUCT AT DOVER.

THOSE who know Dover will remember how the town is cut up by the railway lines to the harbour, and by the Dover and Deal Railway, and have possibly in the past experienced inconvenience at one or the other of the level crossings. In order to improve these conditions a scheme was proposed many years ago, embodying a raised street viaduct, so as to provide permanent communication through certain thoroughfares, regardless of the traffic on the railways. This scheme was authorised first in Acts obtained by the Corporation of Dover in 1901 and 1912, and the contract was actually let for the undertaking in 1913. As was the case with all other big works, the scheme was interfered with by the war, and has only recently been completed, a series of important tests on the work having been carried out as late as September last, while the engineer's report on them was only submitted at the beginning of November.

The improvement scheme involved the construction of a raised road running from close to the north side of Dover Town Station (Beach Street) in a north-westerly and northerly direction, to join Elizabeth and Limekiln-streets at their junction on the west side of the Harbour Station. The scheme also included a spur or branch from the raised viaduct on its western side down into Bulwark-street, while a further overbridge in Limekiln-street took that thoroughfare across the South Eastern and Chatham Railway. The elevation and plan in Figs. 1 and 2, on page 252, show the viaduct and the district involved, and will give some idea of the facilities the new works provide, though these will be most appreciated by those whose business or pleasure has furnished them with actual knowledge of the locality.

The main viaduct has a total length of about 1,000 ft. The spur running from it down to Bulwark-street is about 200 ft. long, while the separate over-bridge referred to in Limekiln-street has a span of 68 ft. The main viaduct also includes two spans respectively, of 70 ft. and 65 ft., the one over Drainage Works, and the other over the Dover and Deal Railway. Starting from the Town Station end the viaduct for a distance of 152 ft. rises gradually between retaining walls, till a length is reached which is carried on a series of arches, of which there are on this side seven, averaging 31-ft. span. The Dover and Deal Railway is next crossed by a bowstring girder bridge, slightly on the skew, and with a clear opening of 65 ft. The viaduct then continues on seven arches of about 31-ft. span, on a curve, when junction is made at a 40 ft. span with the spur to Bulwark-street. After two more 31 ft. and 37 ft. arches comes the second bowstring girder bridge, with a clear span of 70 ft., over the corporation's drainage works. The viaduct ends with a series of six arches averaging 35 ft. span, on a falling gradient. The spur consists of a length on arches, one of which spans New Oxenden-street, and an end section of filling between retaining walls. The separate overbridge of 68-ft. span is a bowstring girder similar to the other two. The whole of this work was carried out in ferro-concrete, on the Mouchel-Hennibique system, and Messrs. L. G. Mouchel and Partners, Limited, Westminster, were associated as consulting engineers

THE NEW STREET VIADUCT AT DOVER.

CONSTRUCTED TO THE DESIGN OF MESSRS. L. G. MOUCHEL AND PARTNERS, LIMITED, ENGINEERS, WESTMINSTER.

Fig. 1.

Fig. 2.

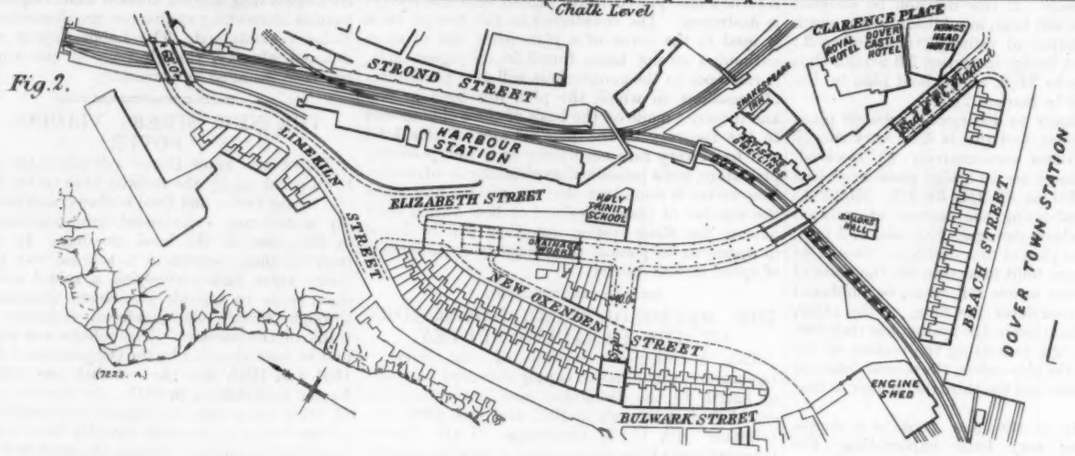


Fig. 3.

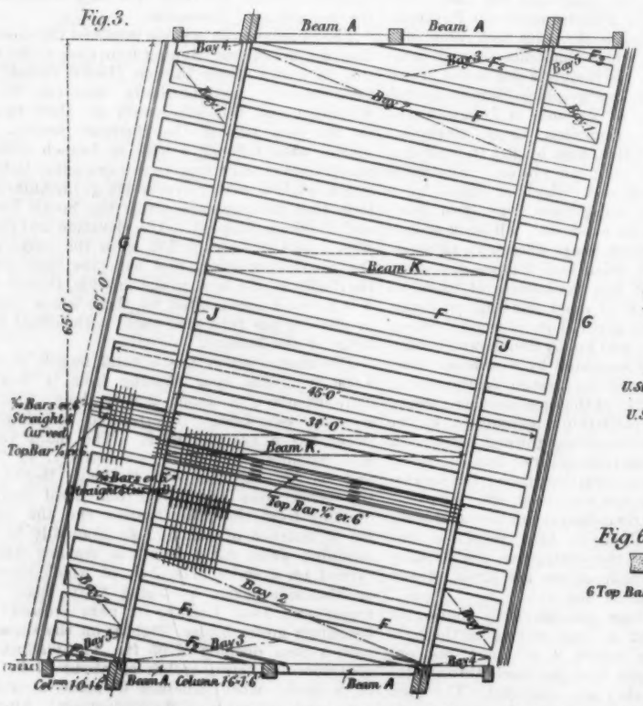


Fig. 4.

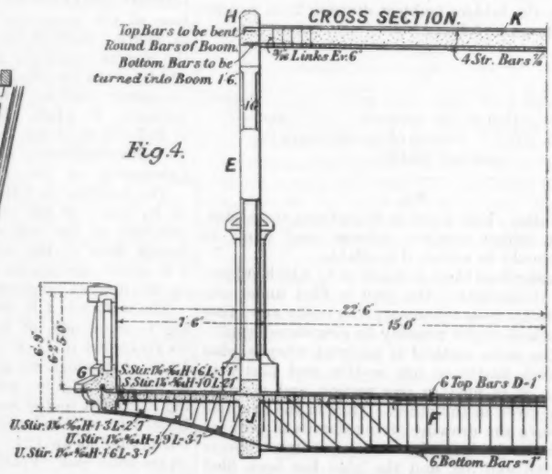


Fig. 5.

Fig. 6.

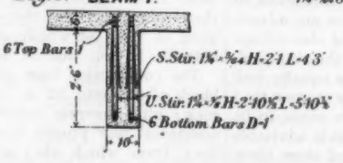
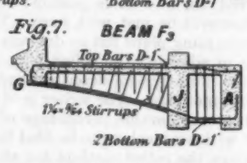


Fig. 7.



for this part of the construction. The contractors were Messrs. Lambrick & Co., Burton-on-Trent, and the whole was carried out under the superintendence of Mr. W. C. Hawke, former Borough Engineer of Dover. At its conclusion independent tests were carried out, to which we shall refer as we proceed. These were conducted by Messrs. D. Balfour and Son, of Kingsway House, W.C. 2, at the request of the Borough Surveyor, Mr. W. Boulton Smith. It may be added that the South Eastern and Chatham Railway Company demanded special tests in the case of the bowstring bridges over their lines, and at these tests representatives of the railway company assisted.

The tests carried out and reported upon by Messrs. D. Balfour and Son were nine in number, while loading conditions during this work were of such a character as to render an investigation possible in a further case, though no actual measurements were taken in this instance. The tests comprised static and rolling tests, and combined tests on various portions, including two of the bowstring girder bridges, two 40-ft. spans of the viaduct, one 33-ft. span, two 31-ft. spans and two contiguous spans of 29 ft. 7 in. each. We cannot deal in detail with all these tests, and therefore must confine ourselves to a few, and to a general summary of the remainder.

In order to give a good idea of the construction we have selected typical portions, to which the other parts conform, except in so far as certain variables come in, due to small differences in span, &c., to suit the locality and the curvature of the viaduct. The parts we thus propose to deal with are one of the earth-filled approaches between retaining walls, the smaller arches, and one of the three bowstring girder bridges.

Commencing with the latter we have selected for illustration the bridge carrying the viaduct over the Dover and Deal Railway. Although this bridge did not involve the longest girders of the three, it was slightly on the skew, and the tests to which it was subjected at the instance of the engineers of the railway company were particularly severe. The bridge is illustrated in Figs. 3 to 19, on the present and opposite pages, and in the views reproduced in Figs. 20, 21

THE NEW STREET VIADUCT AT DOVER.

CONSTRUCTED TO THE DESIGN OF MESSRS. L. G. MOUCHEL AND PARTNERS, LIMITED, ENGINEERS, WESTMINSTER.

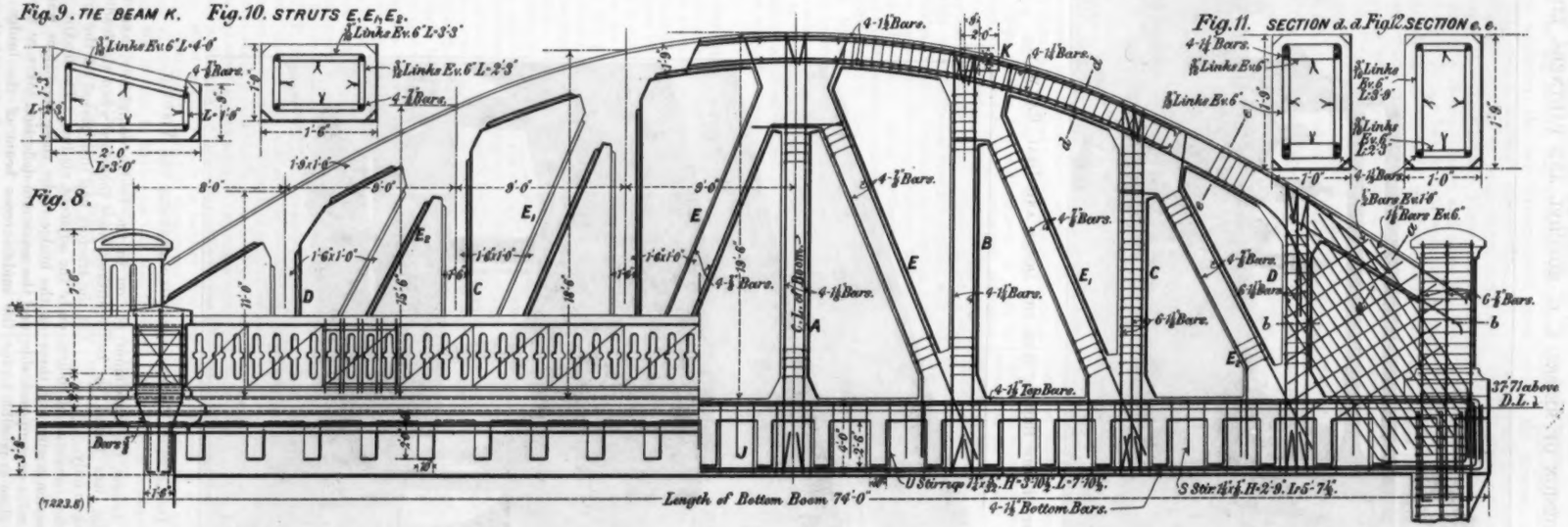
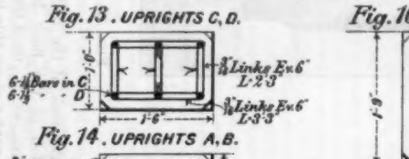
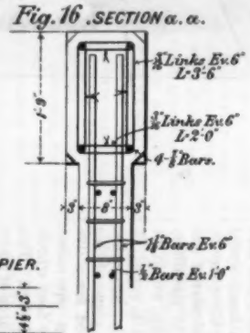
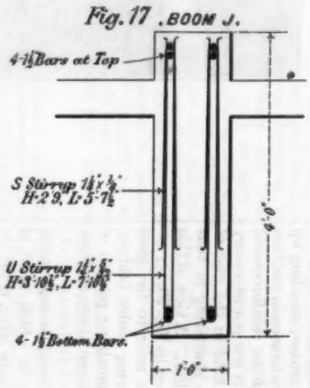
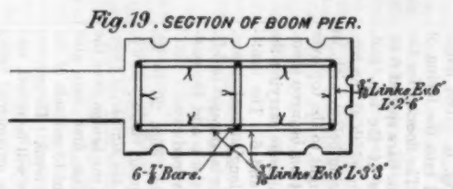


Fig. 9. TIE BEAM K.
Fig. 10. STRUTS E, E1, E2.
Fig. 11. SECTION d. d. Fig 12. SECTION e. e.
Fig. 8.
Length of Bottom Boom 74'-0"
4-1½ Bottom Bars.
4-1½ Top Bars.
U Stirrup 1½ x ⅝. H-3'10½. L-7'10½.
S Stirrup 1½ x ½. H-2'8. L-5'7½.









and 22, on page 264. We may add that Fig. 23, on that page, represents a view of the Drainage works bridge during construction. The clear span of the Dover and Deal bridge is 65 ft., the opening being 67 ft., measured parallel with the girders, while the bottom boom has an over-all length of 74 ft. An elevation of one girder is given in Fig. 8, while Fig. 4 gives a half cross section, and Fig. 3 a plan.

The bowstring girders each consist of six open panels and two end panels filled with reinforced concrete. These girders are 23 ft. 6 in. deep at the centre, from the top to the underside of the bottom boom. The latter is 4 ft. deep by 12 in. wide, reinforced with four 1¼-in. bars at the bottom, and similarly at the top (Fig. 17). The top curved boom is 21 in. by 12 in. in section, the reinforcement increasing towards the centre to eight bars of 1¼ in. and 1¼ in. diameter (as shown in Figs. 11 and 12). The uprights are 18 in. by 12 in. in section, the central member being reinforced by four vertical bars (Fig. 14), 1¼ in. in diameter, and the next on each side by 1¼-in. bars. The remaining four verticals are reinforced as in Fig. 13, with six bars each, the innermost having 1¼-in. bars, and the others 1¼-in. bars. The diagonal struts are uniform and of 18 in. by 12 in. section, with ⅞-in. bars disposed towards the corners (Fig. 10). The solid end panels are shown in section in Fig. 18. The panel slab is 8 in. thick, reinforced with 1¼-in. bars placed diagonally 6 in. apart, while across these are laid ½-in. bars at 12-in. pitch. Fig. 16 shows the manner in which the panel and top chord are combined.

The bridge has a central roadway, and outside pathways carried on cantilevers, as shown in the plan, Fig. 3, and cross section, Fig. 4. The main girders are 31 ft. apart between centres, while from the centre line of the girders to the inside of the parapet, on each side of the bridge, is 7 ft. Overhead the girders are stiffened by two beams of a section shown in Fig. 9, annexed. These are 2 ft. wide, and taper from 15 in. on one side to 9 in. on the other, the reinforcement consisting of four ⅞-in. bars. Fig. 4 shows details of one of the main beams and cantilevers, a section of the former being given in Fig. 7, from which it will be seen that in the centre six 1-in. bars are introduced by way of reinforcement at the bottom, and a similar number

at the top, the beam being 10 in. wide, and extending 2 ft. 6 in. below the 6-in. flooring. The bridge being on the skew at either end, three beams run out at each end as shown in Fig. 3. The middle one of these is shown in Fig. 5, page 252, while the shortest, which amounts to little more than the support for the pathways, is shown in Fig. 6. The longitudinal reinforcement is bonded into the facing of the abutments, in these cases. The flooring for the roadway is 6 in. thick, with ½-in. bars spaced 6 in. apart, placed across the bridge at the top, and, longitudinally, $\frac{7}{16}$-in. bars of 6-in. pitch at the top, and $\frac{7}{16}$-in. bars with similar spacing below, with, in addition, $\frac{7}{16}$-in. curved bars brought to the top over the beams, and passing to the bottom between them.

The reinforcement of the cantilevers carrying the pathway is shown in Figs. 4 and 6. The cantilevers run into an outside longitudinal beam, below the parapet. The ornamental parapet is 5 ft. high. The floor is again 6 in. thick, and the reinforcement similar to that of the roadway.

The illustrations on page 264, Figs. 20 to 23, relate to the two bridges on the main viaduct which, as we have mentioned already, are similar in type. Figs. 20, 21 and 22 are views of the bridge over the Dover and Deal Railway. The first two give respectively a view from a point to one side of the bridge and a view from the deck level. The general neat appearance of the structure will be noted, and attention may be drawn to the ornamental panel parapet on the outside. As this bridge spanned the railway the lines below had to be maintained clear, and for this reason the shuttering, &c., for a great part of the span was carried by trusses standing up above the deck level. These may be seen in position in Fig. 22, which shows some of the reinforcement for the main girders in place. As it was not necessary to make provision of the same kind in the case of the drainage works bridge, the shuttering in that case was carried by timbering below. A view of this bridge during construction is given in Fig. 23.

It will be convenient now to refer to the tests which were made on the bowstring girder bridges, reserving a description of the remaining portion of the viaduct with the tests made on those sections for a later article.

The first tests which we shall consider were made on the bowstring girder bridge to which most of our illustrations refer. These tests were made in association with the railway company's engineers, and to their requirements. The first test consisted of a load on one of the secondary beams. The load of road metalling supported by such a beam would be 1 ton 10 cwt., the area of floor being 93 square ft. The load for which the viaduct was calculated was 140 lb. per square foot, in addition to metalling. This, on this area, including metalling, would be 7 tons 6½ cwt. Taking a test load of 210 lb. per sq. ft. —*i.e.*, 50 per cent. above the calculated load—the amount would be 10 tons 4½ cwt. In place of this test the engineers of the railway asked for a distributed load of 41 tons, giving an equivalent bending moment to that produced by four wheels loaded with 7½ tons each on the span of 31 ft. This corresponds to a distributed load on the area of about 1,000 lb. per square foot. In order to take the worst case of concentrated load two tram rails were placed over the beam selected, and running in the same direction. Across these were placed sleepers loaded with ballast. The bottom flanges of these rails, placed close side by side, brought the whole load directly over the 12-in. beam. The rails weighed about 1½ tons. In addition, distributed load at the rate of 210 lb. per square foot was placed over the cantilevered portions carrying the footpaths. The loading for this test is shown in progress in Fig. 24. The deflection allowed by the specification was $\frac{1}{800}$th of the span. Loading was commenced at 3.15 p.m. on September 13, and concluded at 4.50 p.m., when the maximum deflection at the middle of the beam, recorded by instruments set below, was 2 mm. The manner in which the deflection meters were arranged is shown in Fig. 25, which, however, actually illustrates a test on another portion of the viaduct. The instruments were fixed on a stiff base, and the deflection was transmitted from the bridge member to be tested, by means of suspended wooden rods, as will be clearly followed from Fig. 25. In the test now under notice, deducting the deflections of the main beams, the maximum deflection of the floor beam was found to be 1·25 mm., or $\frac{1}{1260}$th of the span only.

The next test on this bridge consisted of rolling load tests, first with one traction engine and three trailers, and then with two trains so composed, side by side, and both passing as close as possible to the girder on one side of the bridge. The traction engines weighed 14 tons each, and the loaded trailers 12½ tons each. These trains were just too long to get on to the bridge completely, and the worst conditions were therefore when the leading wheels of the tractors had just passed off the bridge itself on to the adjacent viaduct. The maximum loading on the bridge under these conditions was 96 tons, and the maximum deflection taken at the centre of the middle cross beam of the bridge measured 1·5 mm. The mean deflection at the centres of the main girders was 1·05 mm., giving ·04 for the cross-beam deflection. These worst deflection for

THE NEW STREET VIADUCT AT DOVER.

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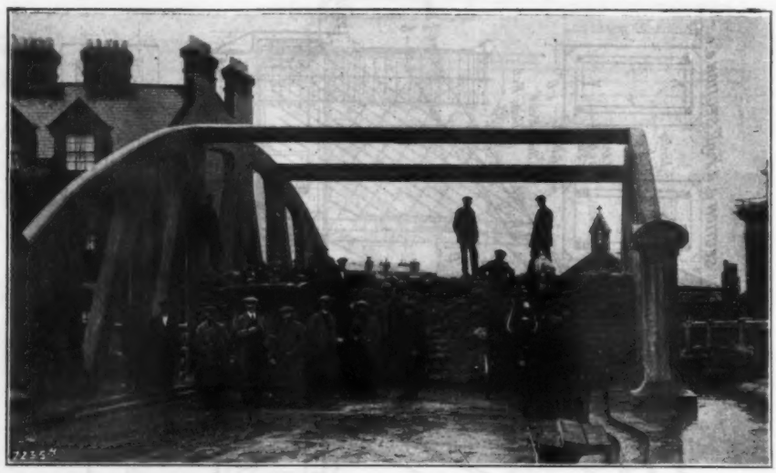


FIG. 24. TEST OF THE BRIDGE OVER THE DOVER AND DEAL RAILWAY.

FIG. 25. DEFLECTION METERS ARRANGED BENEATH THE VIADUCT.

the main girders worked out in this case at $\frac{1}{17,780}$, and for the secondary beam at $\frac{1}{21,000}$ of the span, compared with an allowable $\frac{1}{600}$th. No permanent set was recorded. During this test the railway engineers checked the two main girders for spread at the centre of the top booms, but detected no lateral movement whatever, the two ferro-concrete cross ties resisting such a tendency effectively.

On the bridge over the drainage works tests were carried out with rolling loads. These consisted in the first test of a 14-ton tractor, and three 12½-ton trailers. This bridge has a clear span of 70 ft., and all the wheels of this train, making a total load of 51½ tons, could be got over the span. The second test was made with two similar trains, or a total load of 103 tons. Under the worst load the greatest deflections of one of the main girders was $\frac{1}{111,250}$ of the span, and the greatest deflection at the centre of the middle cross beam, considered by itself, was $\frac{1}{13,700}$ of the span. These compare with the $\frac{1}{600}$ allowable.

(To be continued.)

NOTES ON NEW BOOKS.

The Washington Conference on disarmament has created a somewhat special interest in the existing strength of the navies of the world and in the nature of the vessels of which that strength is composed. The new edition of Janes' *Fighting Ships* (London, Sampson, Low, Marston and Co., Limited, 1921, price 2*l.* 12*s.* 6*d.* net) includes the official text of the United States proposals on disarmament, so that the reader can study them in the fullest possible light of knowledge concerning the warships of all nations. Jane's *Fighting Ships* is far too well known a work to need either commendation or extended reference. The principal innovations in the new edition—which, though appearing at the outset of 1922, is called the 1921 edition—are the special memoirs dealing with the United States, French, Japanese and Italian navies, which are most valuable contributions to naval information. The work gives particulars concerning more than 6,000 warships, and as practically the whole of the contents have been examined, corrected and approved by the various navy departments and ministries concerned, the publishers confidently claim for the facts a very high order of accuracy. The volume is encyclopædic in its scope and is an indispensable work of reference for those who are concerned with naval matters.

That there is no royal road to the acquisition of mathematical knowledge is an adage as true to-day as it was when first formulated some thousand years ago. The study being a difficult one at the best there is no excuse for complicating it by the barriers which a certain type of pure mathematician seems desirous of placing in the path of the student. To such a mathematician the proofs founded on mechanical or geometrical intuition are anathema, because forsooth he can devise functions to which such methods of proof are inapplicable. These peculiar functions, moreover, are purely artificial, being merely ingenious imaginings of his brain, and having for the most part no resemblance to any function actually met with in the investigation of the heavens above, the earth beneath or the waters under the earth. We would not deny that the study of such abnormalities is a perfectly proper and legitimate pursuit, but its devotees have no right to close the easier paths based on mechanical and geometrical considerations to the student, to whom mathematics is to be an implement and not an end. Fortunately, common sense is proving too strong for the cranks, and recent text books on the calculus prepared for the use of the engineer and physicist follow more and more the lines laid down by the founders of the science. Thus Mr. F. F. P. Bisacre, M.A., B.Sc., in his treatise on "*Applied Calculus*," has ventured to reintroduce the commonsense notion of infinitesimals of different orders, a procedure which would hardly have been practicable ten years ago when the doctrine of limiting values was proclaimed as the only orthodox one, even by the very men who when engaged upon an inquiry into real phenomena invariably adopted themselves the infinitesimal methods. For our own part we should have liked Mr. Bisacre to have gone one step further and to have introduced the differential calculus as a logical development of the calculus of finite differences. The average student when he first takes up the study of the former subject has little difficulty in mastering the rules and in working out the examples set for practice, but more often than not he fails to realise the aim and end of the science, or to acquire any very definite idea as to the nature of a function and of the utility of studying its rate of variation. The interpolation formula of the calculus of finite differences, on the other hand, shows him at once the utility of certain operations, and gives him a good idea of the meaning of a rate of change. It is perhaps significant that Taylor's theorem, which has been called the most important in the whole range of analysis, made its first appearance in a treatise on finite differences. General principles are, however, excellently dealt with in Mr. Bisacre's opening chapter, but we think that it would have been preferable to have discussed "limits" after, rather than before, the chapter on infinitesimals. In this chapter, moreover, he proposes to denote a differential by δy, although this has been allotted an entirely different signification in the calculus of variations. Problems in geometry and mensuration have adequate space allotted to them; though proportionately less than in most treatises, the author preferring to take his illustrations from electricity, chemistry and thermodynamics, to which about one-third of the treatise is devoted. The book seems unusually well adapted to the needs of those for whom it is devised. It is published by Messrs. Blackie and Son, Limited, at the price of 10*s.* 6*d.* net. There are 447 pages of text, and numerous diagrams and other illustrations.

The foundry, as we have had occasion to remark before, is one of the least generally understood departments of an engineering works, and far too few of the men who design or use castings have any proper conception of the art by which they are produced. Foundry work is neglected as a subject of teaching in our educational establishments, partly because it does not lend itself to demonstration on a small scale, and partly for the reason that its processes are not appreciated by academic minds. We believe that the Cast Iron Research Association recently founded under the auspices of the Department of Scientific and Industrial Research aims to do something to improve education as regards the foundry, and we wish it success in its efforts. Meanwhile any good book on moulding is welcome, and in *Iron Founding*, by B. Whitely (London, Sir Isaac Pitman and Sons, Limited, Kingsway, 1921, price 3*s.* net), we have a little volume that can be recommended as a clearly-written, well-balanced and practical review of modern foundry practice. What the moulder does and how he does it are explained in a simple and interesting manner, by a writer who obviously knows what he is talking about and who has the ability to express himself. The book might well be acquired by all students of engineering and particularly those who have not the opportunity of getting first-hand practical experience in the foundry.

A common fault in elementary books of exposition is an attempt to cover too much ground—too much ground not at the end of the book, but at the beginning. This remark does not apply to elementary text books proper—these can hardly pay too much attention to foundation principles—but to the class of book so common nowadays which deals with a process, art or branch of science in an elementary way. An excellent example of the kind of thing we have in mind is furnished by Mr. Frank J. Moffett's primer on "*The Electric Furnace*." This is in general an entirely satisfactory production, and there should be room for this simple review of a subject which is comparatively new to commercial practice. Mr. Moffett, however, falls into the error we have mentioned and actually begins by defining an ampere and volt, and stating Ohm's law. As he naturally cannot devote adequate space to electrical fundamentals, his chapter on "First Principles" is of no value. To anyone completely ignorant of electrical matters the chapter could mean nothing and to anyone else it is unnecessary. The futility of attempting to teach electrical science as well as describe electric furnaces in a book of this size is illustrated by the fact that although Mr. Moffett defines Ohm's law for the benefit of the uninitiated, the same uninitiated are later supposed to know what a static transformer and electric induction are without explanation. A book on electric furnaces must presuppose some knowledge beyond understanding of the English language, and if a reader finds he wants to know what a volt is, let him buy "Little Willie's First Steps in Galvanism." Apart from this criticism, Mr. Moffett's book is welcome and useful. It is published by Messrs. Sir Isaac Pitman and Sons at 2*s.* 6*d.* net.

The Mineral Researches Committee of the Imperial Institute is doing very useful work by issuing a series of monographs on mineral resources, in amplification and extension of those which have already appeared in the Bulletin of the Institute. The object of these monographs is to give a general account of the occurrences and utilisation of minerals especially in the British Empire. The monographs on "*Oil Shales*," by Dr. H. B. Cronshaw [John Murray, price 5*s.* net] points out that many parts of the world fortunately contain immense deposits of materials capable of yielding oil on distillation. The oil shales are distinguished as true shales or kerogen shales, laminated dark brown or black rocks, resembling hard dark wood, of density 1·7 to 2·3; torbanites, density 1·008 to 1·5, burning like candles with a crackling noise; and cannel coal. Whilst an English law court classed the torbanites with coals, the German courts decided that torbanite was a bituminous shale; the distinction is not easy therefore. In England shales are found in many counties, in the lower division of the Upper Oolites (Jurassic), interstratified with the Kimmeridge clay; they are missing in Suffolk, Essex, Hertfordshire, Middlesex, and in parts of Surrey and Kent. The shales are frequent, of course, in Scotland and not rare in the north of Ireland, but split up by faults in the latter case into numerous divisions. Many of the dominions are well supplied with oil shales, and further search may reveal their occurrence in others. A good literature list is appended to the pamphlet of 80 pages. There is no reference to India.

If an enlightened ruler, such as her present President of the Republic, Hsu Shih-Chang, had been at the head of affairs in China commencing centuries ago, that country would not have been the "unknown quantity" she is to-day, and both China, together with every other nation, would greatly have benefited by it; at all events, the map of the world would be very different from what it is now. Evidence is afforded that China will henceforth enter actively into the committee of nations by the fact that a book, "*China After the War*," has been written by Hsu Shih-Chang, an English translation of which has been prepared by the Bureau of Economic Information, Peking. As it deals with China "after the war," it opens, and very naturally so, with a survey not so much of the war itself as of the effects it has had upon the belligerent and the neutral nations. Following this are two sections covering "China's Past and Present," and "The China of To-morrow and the World," both of which review the history of the country, the characteristics of the people, education, trade and industry, and China's relations with other nations. Another instance of Chinese business activity is afforded by the very able notes on mining, trade and banking in the country—notes which are periodically issued by the Bureau above referred to, whose address in Peking is 6, Hua Yuan Ta Yuan, and in Shanghai, 95, Foochow-road.

An account of the rainfall in the United Kingdom during the year 1920 is contained in "*British Rainfall*," 1920, the sixtieth annual volume of the British Rainfall Organisation, which can be obtained at the price of 12*s.* 6*d.* net, from H.M. Stationery Office, Imperial House, Kingsway, W.C. 2. It was issued in the early days of last December. From this we find that the average over thirty-five years, from 1881 to 1915, for the British Isles taken on 216 records, was 38·77 in., whereas in 1920 the average was 42·32 in. The general rainfall of the year was in excess of the thirty-five years' average in each country, though in England and Scotland the large dry areas in the East nearly counterbalanced the wet areas in the West. Wales was markedly wet and Ireland also had a substantial excess. The book gives evidence of the very large amount of intricate work necessary to arrive at the above and the other figures quoted. In view, however, of the extraordinary weather conditions which ruled last year, we fear the account for 1920, only now available, will lose much of the interest it would otherwise have had for the general public. We may refer our readers to an article published in "*La Nature*" for January, by a member of the French Meteorological Bureau, giving data for 1921 concerning France, and showing, among other figures, that the French rainfall in 1921 was 47 per cent. of the normal, the number of rain days being 69 per cent. also of the normal.

ROOFING TILES IN EAST AFRICA.—In several countries in Africa it has been suggested that roofing tiles should be made locally, and search has been made for suitable materials. Specimens of clay and sand, collected in Uganda, and of clay and diatomite from Kenya Colony, have recently been examined at the Imperial Institute in order to ascertain their possibilities in this direction. The Bulletin of the Imperial Institute states that tiles of good quality can be made with a suitable mixture of the clays and sand from Uganda, whilst good tiles can also be made from mixtures of the washed clays with "grog," *i.e.*, clay which has been burnt and finely ground. The clays from Kenya Colony were also found to be suitable for making roofing tiles. The results obtained with the infusorial earth or diatomite (which contained a certain proportion of clay) are of special interest, as this material, which does not appear to have been employed previously for the purpose, furnished tiles which were much lighter than ordinary roofing tiles, this being a great advantage. It may be added that there are extensive deposits of infusorial earth in Kenya, not at present worked.

THE POLAK HYDRAULIC TRACTION DYNAMOMETER.

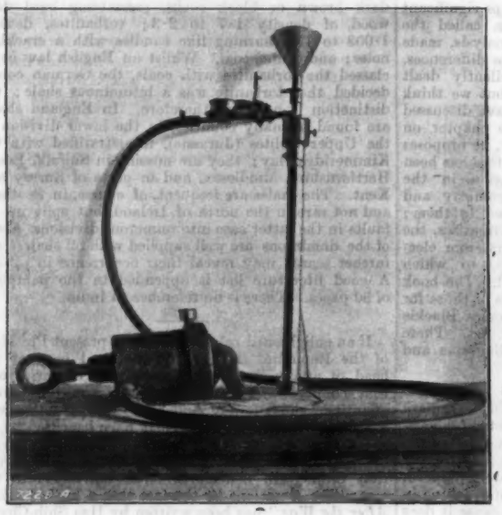


FIG. 1.

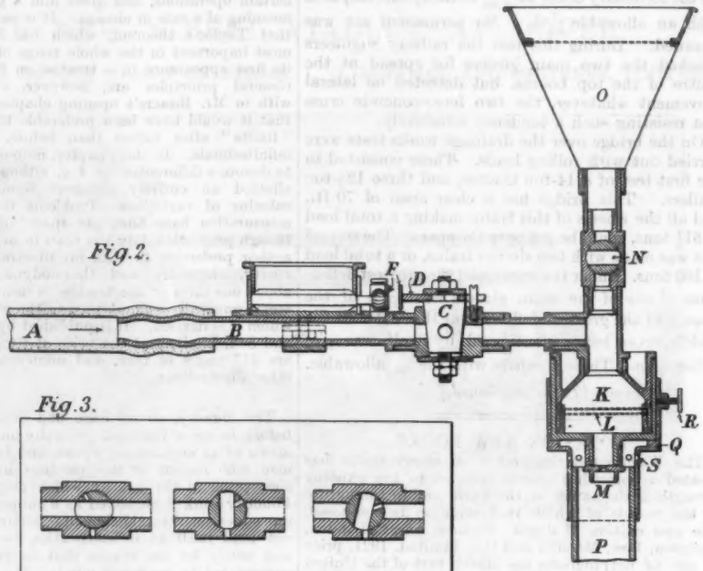


Fig.2.

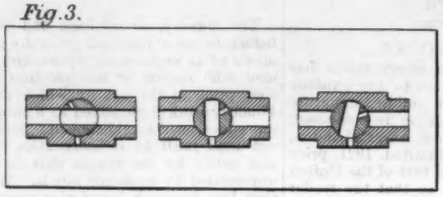
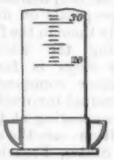


Fig.3.



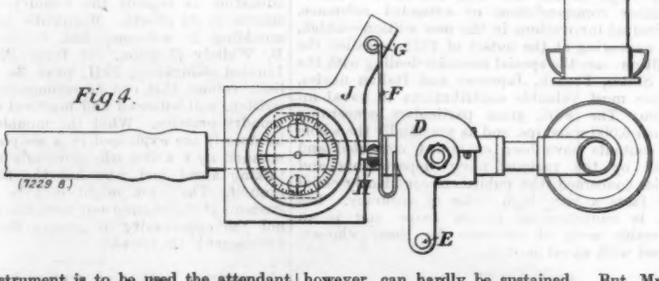


Fig 4.

IN 1920 the Royal Agricultural Society and the Society of Motor Manufacturers and Traders approached the National Physical Laboratory with a request for assistance in the construction of an instrument for measuring the draw-bar pull and speed of a tractor under ploughing conditions, to be used in the competitive trials, which were subsequently held near Lincoln in September and October of that year. No suitable British-made draw-bar provided with recording apparatus was available at the time. The hydraulic instrument used in the trials, which Mr. J. H. Hyde designed and which was made at the National Physical Laboratory, was described in our issue of November 26, 1920. This was afterwards superseded by the Watson dynamometers, used at Shrawardine.

The dynamometer which Mr. Hyde couples between the tractor and plough consists of a cylinder and plunger; the pull on the coupling results in pressure on the oil in the cylinder. This pressure is transferred by a flexible tube to a recording gauge of the Schäffer-Budenberg type mounted on a carriage which also carries the speed indicator. The dynamometer, which we now illustrate in Fig. 1 and the diagrams Figs. 2 to 4, annexed, is also hydraulic and designed for testing agricultural machinery. But the liquid is water which the piston forces through a small aperture into a graduated cylinder; the instrument thus does not draw a curve, but measures the average draw-bar pull during a certain period, mostly of 20 seconds. Further, this dynamometer does not indicate the speed; it requires no special carriage, but, not being automatic, it needs an attendant. As described by its designer, Mr. M. W. Polak in last year's "Mededeelingen der Landbouwhoogeschool, vol. xxi, number 3,* this dynamometer has not yet taken its final form. But the determination of the pull by the volume of the water forced out of the dynamometer cylinder is novel, we believe, for such instruments, and Mr. Polak's experiments on the reliability of several dynamometers of various types coupled in series have an interest of their own.

The instrument consists of several parts, to be connected up when wanted: A copper cylinder, a rubber pipe for high pressures, the measuring device forming a T-piece, provided with a funnel, and a glass cylinder calibrated in cubic centimetres. The copper cylinder has a diameter of 10 cm. (4 in.), a stroke of the same length and weighs 10 kg. The connecting rubber hose A (Fig. 2) has a length of 2 m. It is pushed over the end of the pipe B which is closed by the tap C leading to the vertical tube N M which carries the funnel D at the top and opens out into a cylindrical chamber K L; M is the aperture, 0·7 mm. in diameter, through which the liquid is forced out, and K and L are wire gauze screens of 1 mm. mesh inserted to keep any dirt away from M. The measuring cylinder P and its copper collar Q are held in position by the screw R.

* A reprint has been published by Messrs. H. Veenman, of Wageningen, Netherlands (at the price of 1.30 guilder.) We are indebted for our particulars to the Secretary of the Mededeelingen.

When the instrument is to be used the attendant places the cylinder on the ground and suspends the tubular portion by a cord from his neck. The piston is drawn out, and taps C and N are opened; water is poured into the funnel, and the piston is pushed back, the air in the cylinder escaping through a hole (not shown in the illustrations); both the taps C and N are then closed again. The graduated cylinder is next attached to the chamber K L, and the main cylinder is suspended by hooks between the tractor and the plough. The attendant holds the instrument by one hand and opens the tap C by turning the handle D E (Fig. 4). The spring F G then presses on the stud H, and the stop-watch J is started. After a period, generally of 20 seconds, C is closed again; the different positions of C are indicated in Fig. 3. The water discharged during the period of the experiment collects in P. If the tap should be kept open for more than 20 seconds, the amount of water discharged would naturally increase proportionately.

There are various theoretical and practical difficulties arising from water leakage in the piston and from other features. But those troubles are not serious, and the main difference between this dynamometer and others is that the Polak instruments show the average tractive effort during a period of 20 seconds or more and not the fluctuations. Sometimes it may be desirable to know the maximum resistance to be overcome. That maximum will, however, depend upon the accidental occurrences of stones, &c., and in general the engineer will be more interested in the average power he has to supply which the mean level of the curve drawn, apart from the serious momentary fluctuations, will indicate. The instrument as described was designed for a maximum effort of about 1,000 kg. When larger forces are to be met, Mr. Polak makes use of a scissors or X-lever suspension device; he attaches the upper short arms of the X by shackles to the tractor and plough and suspends the dynamometer cylinder between the lower, long arms.

Ordinary spring dynamometers are known not to be very accurate. It has in fact been suggested that the springs tend to act as buffers storing up energy and thus give indications which are too low. That view, however, can hardly be sustained. But Mr. Polak observed that when he coupled several dynamometers in series, his own kept in satisfactory accord, whilst spring dynamometers deviated a good deal from one another. The spring dynamometers he experimented with were of three types: Schäffer and Budenberg; Burg; and Sack. He found, for instance, that these recorded in kilogrammes 313, 463, 323 in one test, and 357, 463, 351 in another of the same series. The Schäffer-Budenberg and Sack instruments were usually in fair agreement, i.e., within about 10 per cent., whilst the Burg dynamometer differed by 28 per cent. and more. In any case the curves were naturally all very irregular. On the other hand, two Polak dynamometers coupled in series kept in accord within 0·44 per cent. throughout series of tests. The Sack and Schäffer instruments gave sometimes higher and sometimes lower values, but they did not differ by more than a few per cent. from the hydraulic instruments on the average. Much will in such comparisons depend upon experimental conditions and the peculiarities of each instrument, and the figures are for these reasons not strictly comparable. We should mention that Mr. Polak's hydraulic dynamometer is not patented.

THE RUMANIAN DANUBE BRIDGE AT CERNAVODA.—The railway connecting Bucharest with the port of Constanza on the Black Sea crosses the two arms of the Danube, the Danube proper and the Borcea, in a series of bridges and viaducts altogether over 14 km. in length, consisting of the Cernavoda Bridge, a viaduct across the island of Balta, and the bridge across the Borcea over the Fetesti. The bridge system was partly destroyed during the war in 1916. The Cernavoda Bridge was restored by the Gustavsburg works of the Maschinenfabrik Augsburg-Nürnberg, as we described in our issue of June 18, 1920, pages 837 to 840. The viaducts were also restored, but the traffic over the Borcea was for some years carried on by ferries, and the service across this restored bridge was only reopened last December. The girders utilised, 103 m. in length, were taken by the Rumanian army in Budapest; they had been constructed for a bridge across the Save in Bosnia. The central span, measuring 37 m. in length, was built by the Reschitza iron works. These works are situated in what is now Rumanian territory.

WATER-TUBE BOILER FITTED FOR BURNING BROWN COAL.

Fig. 1.

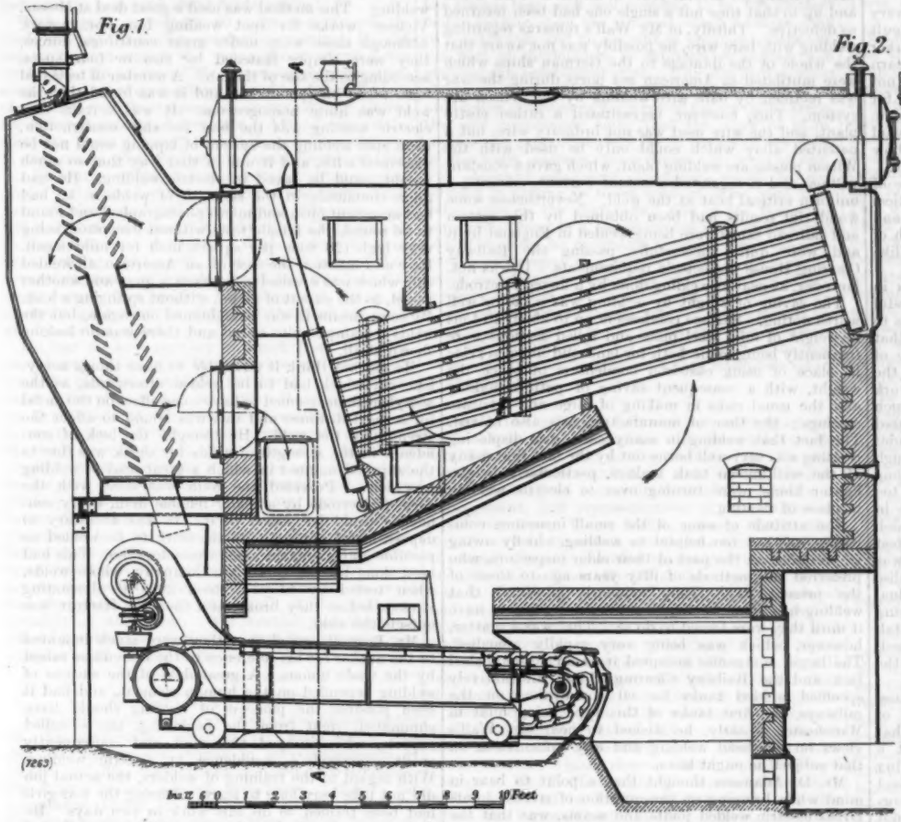
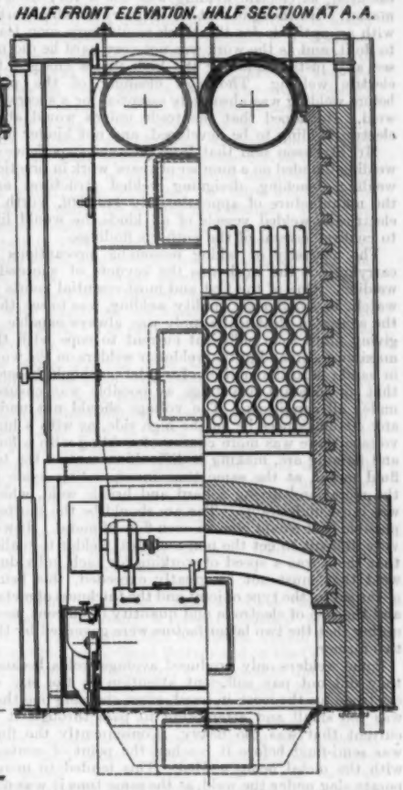


Fig. 2. HALF FRONT ELEVATION. HALF SECTION AT A.A.



ELSEWHERE in this issue we refer to Dr. W. A. Bone's lecture delivered before the Royal Society of Arts last Friday on "Lignites and Brown Coals." On that occasion Dr. Bone referred to an apparatus which had been applied to a Babcock and Wilcox boiler for improving and "up grading" Morwell brown coal before feeding it on to the grate. Through the courtesy of Dr. Bone we are enabled to illustrate this installation in Figs. 1 and 2 above. The boiler has been fitted up for trial purposes to the order of the Victorian Government Electricity Commissioners, the so-called "Fuel improving" attachment being designed by the Underfeed Stoker Company, Limited, Coventry House, South-place, E.C. 2. It is used in conjunction with one of the same company's self-contained forced-draught travelling grate stokers.

The heating surface of the boiler is 2,436 sq. ft., and the grate area of the stoker 85·7 sq. ft. The boiler is fitted in front with a large casing within which is arranged a large chute formed with two parallel inverted louvre sides. The chute is 1 ft. in section, back to front, about 15 ft. long and 7 ft. wide. Half way down the chute an horizontal diaphragm extends partly across the casing, and the arrows indicate the path taken by the waste gases. The chute is fed from a hopper overhead, and has a capacity of a little over 2 tons of fuel; about 45 minutes are occupied by the fuel in passing completely through the apparatus to the grate. During this time it is exposed to the hot gases, and the greater part of the moisture and CO_2 are driven off, the fuel as burnt being consequently of greater steam-producing value. Owing to the liability of dry, powdery brown coal to ignite, it is an essential part of the process that the temperature should not be high, and that there should be present in the waste gases passing through the improver, about 10 per cent. of CO_2. In order to minimise the risk of ignition the hot gases are brought into contact with the raw fuel in the upper portion of the chute. It is hoped that the present trials will show that this direction can be safely reversed and the hotter gases brought in contact, on the contra-flow principle with the fuel as it is being delivered to the stoker. In the article on page 267, we have given some preliminary results obtained with this apparatus, and it is not necessary therefore to repeat the figures here.

STEEL FURNACES IN JAPAN.—The present open-hearth furnace capacity of Japanese steel works is given as 2,471 tons, divided over a total of 105 furnaces.

THE INSTITUTION OF MECHANICAL ENGINEERS.

NORTH-WESTERN SECTION.

THE paper by Mr. A. T. Wall, on "Electric Welding Applied to Steel Construction, with Special Reference to Ships," which was read and briefly discussed in London on February 17, as reported in our issue of the 24th ult., was further discussed before the North-Western Section of the Institution of Mechanical Engineers, on Thursday, the 23rd ult., at Manchester. This paper we may mention was reprinted in our columns, page 241 *et seq.*, *ante*.

The discussion was opened by Mr. C. E. Stromeyer, who said it was very regrettable that the development of electric welding had been hampered by the trade unions. He knew of an instance of a vessel on the Tyne, which although it had been started could not be finished owing to trade union regulations. It was very gratifying that the Fullagar had stood the test of heavy weather with a cargo which produced a very severe strain. There were not many cases of ships having torn their plating, although Mr. Strawson knew of one, owned by the Monarch Line, which had a fire at sea. This was put out by the usual appliances, but before reaching port the ship had a rent in her side 16 ft. long. When the plates were taken out they were as brittle as glass, this evidently being due to the quenching of the red hot plates while they were under strain, although mild steel should not be brittle under ordinary quenching.

It was mentioned in the paper that by reducing the scantlings of a ship a reduction in the whole weight would be effected, but although this was a very desirable object, it would mean redesigning ships altogether. He was with Lloyd's Register in the early days of steel, when it was realised what wonderfully good properties it had compared with ship iron. Those plates would just stand punching, but not bending, and therefore could only be used for the flat parts of the ship. In spite of the change from that very bad material to mild steel, Lloyd's found that the reduction of 20 per cent. in the plates was too much. This was not admitted at first, but gradually ships built under the first set of rules had to be stiffened, and the new ships were made with thicker plates. The need for plates thicker than hypothesis required was due to the wave action. A notable example of this was a Russian ship built by a man who had evidently got a contract which enabled him to do what he liked. He spaced the frames 4 ft. apart instead of 2 ft., and used very thin plates, his excuse being that as the vessel was flat and large, the plating would not be subject to wave action. But when she did get out and into the Bay of Biscay, the plates slammed, and after putting into a Spanish port she slowly got round to the Black Sea, but was never used again. When welding became general, some modification would have to be made in spacing the frames if a reduction in weight was aimed at.

Some years previously he had fitted strain indicators on board torpedo destroyers to make experiments, and found that strains registered by these instruments agreed very closely with the strains which calculation showed ought to exist, thus confirming naval architects in the correctness of their views. No further experiments had been made, but there were many parts of the structure of the modern battle ship which deserved careful study. He had always taken an interest in strains in ships, and drew attention to the opening remarks about the riveting of ships, where the author took it for granted that all ships had vertical seams all lap jointed. That was the case, but in 1880 the ships then built had plates riveted with single butt straps. He had made experiments with strain indicators placed above or below one of these internal butt straps and obtained quite distinct readings, showing that there were very considerable strains just above and below the butt strap. In the middle of the plate, however, no readings could be obtained, confirming the theory that a single butt strap was strained about seven times as heavily as the plate itself. That could be calculated if the bending strain in the butt strap and in the plate were taken into account. That severe straining was very likely the cause of leakage at butt straps. It could be demonstrated by a simple experiment with a strip of paper, shaped like a single butt strap, with the ends of the strip reduced to one-seventh the width of the strip. When this strip was placed between two pieces of glass and subjected to strain, it did not tear at the thin ends, but through the butt strap. The effect of that was that lap joints were used instead of single butt straps. It was very desirable that if electric welding still further reduced strains that it should soon come into regular use. He had every confidence in welding by good men and with good material, and although he had heard of failures with acetylene welding, he did not know of any where electric welding had been used. Boilermakers seemed very fond of the latter method. He knew of cases of patches of corrosion 3 ft. or 4 ft. square, where it was thought cheapest and best to fill it up with electric welding, and although he did

not really approve of this, the boilers had worked quite satisfactorily after this repair.

He did not regard the training of welders as very essential, as electric welding was not a very difficult matter. He thought that an ordinary sensible worker with an aptitude for this work would very soon learn to do it, and as the work was not very hard he did not see any justification for the high prices charged for electric welding. Thorough cleaning of the plate before welding was absolutely essential for a successful weld. He hoped that the trade unions would allow electric welding to be developed, and not hinder it.

Mr. Strawson said that from personal experience of welding founded on a number of years' work in practical welding, teaching, designing welded structures and the manufacture of approximately 440,000*l.* worth of electrically-welded vessels of all kinds, he would like to confirm several of the author's findings.

The necessity of taking reasonable precautions in carrying out the work was the keynote of successful welding. One of the first and most essential points to watch, to avoid poor quality welding, was to see that the source of electrical supply was always capable of giving more than sufficient current to cope with the maximum demand of the welder or welders on the work in hand; also the method of regulation should be such that as constant a voltage as possible was ensured under all conditions. The voltage should not under any circumstances be on the high side, as with a high voltage there was more chance of welding with a long and flaming arc, making it difficult to control the too fluid metal, at the same time incorporating oxide in the metal and giving a hard and brittle weld, which was most undesirable. The arc should be the shortest possible that would give an even flow of metal. It was very difficult to get the non-technical welder to realise that there was a speed of working for each individual weld that must not be greatly exceeded, this being governed by the type of joint and the thickness of metal, and the size of electrode and quantity of current used, noting that the two latter factors were governed by the two former.

Some welders only produced average welds because they did not pay sufficient attention to the size of electrode for the work in hand, often choosing one that was too small and attempting to pass through it a current that was too heavy. Consequently the flux was semi-fluid before it reached the point of contact with the metal being welded. This tended to incorporate slag under the weld, at the same time it was not possible to pass sufficient current properly to melt the relatively heavier metal to be welded. The welder would be well advised to adjust the amperage by the actual flow of metal by trial, rather than by consulting a book as to what was the correct amperage for a given electrode.

The electrode itself should not be overlooked, and in this there was too much prejudice shown. One firm would only use one type of electrode, another firm would swear by a different type, instead of each firm keeping a supply of all the well-known and reliable makes, and using them in accordance with what was required on the particular work in hand. To use one type of electrode for all work was a great mistake and likely to lead to biassed opinions that were not helpful to the furthering of the cause of welding.

It was surprising what strength was obtained on an average weld when tested to destruction. He was able to exhibit several examples of welding. These were pieces of metal picked off the scrap heap and welded up without even the rust being cleaned off. They had been tested to a much greater stress than they would have been subjected to if forming the part of a structure. One example was particularly interesting, as the same result would have been impossible in riveting, owing to the fact that the caulking could not have been kept tight under the test pressure. A piece of old ½-in. galvanised plate 12 in. in diameter was welded by a single light run of weld of only average quality to a 1 in. thick plate and was then tested hydraulically until the plate bulged to a permanent set. The weld then split along the edge for about 2 in., at a pressure of 350 lb. per square inch. Several rough runs of weld were then put over the old weld and the plate again tested to 650 lb. per square inch when the testing pipe burst, leaving the plate still intact. As well as the plate being galvanised, the edges were oxy-cut and welded without cleaning, the experiment being done to see what would happen under extremely bad conditions of material and workmanship.

There were some points upon which he disagreed from the author. Firstly, it was not possible to train an efficient welder in two months' time to undertake every type of work that came along, and secondly, that edges that had been oxy-cut did not allow good welds to be made. If the oxy-cutting was fairly good and the oxide knocked off the edges of the plate, the use of the correct electrode solved this problem every time. Thousands of feet of oxy-cut edges were welded in Manchester every week and the vessels and tanks constructed from them were tested to anything up to 850 lb. per square inch. Many hundreds of them had been working for several years in all parts of the world and up to that time not a single one had been returned as defective. Thirdly, in Mr. Wall's remarks regarding welding with bare wire, he possibly was not aware that the whole of the damage to the German ships which were mutilated in American sea ports during the war was rectified by bare wire welding by the Wilson arc system. This, however, necessitated a rather costly plant, and the wire used was not ordinary wire, but a patented alloy which could only be used with the Wilson plastic arc welding plant, which gave a constant voltage and a regulated constant current, ensuring a uniform critical heat at the weld. Nevertheless some wonderful results had been obtained by this system and railroad tanks were being welded in England by it and were quite successfully passing the Railway Clearing House inspector's requirements. It was not, however, as neat as welding done by a fluxed electrode.

The saving of weight by welding was a factor well worth noting. Surface condensers up to about 10 tons in weight of mild steel plate and rolled sections were frequently being made both for land and naval service in place of using cast-iron condensers of twice the weight, with a consequent saving of pattern-making and the usual risks in making of large and intricate castings; the time of manufacture was also halved. The fact that welding in many cases was displacing riveting was very well borne out by the fact that many of the well-known tank makers, particularly in the lighter kinds, were turning over to electric welding in place of riveting.

The attitude of some of the small insurance companies was not too helpful to welding, chiefly owing to prejudice on the part of their older inspectors, who preferred the methods of fifty years ago to those of the present day. They evidently admitted that welding had come to stay, but were not going to have it until they were forced to do so. That was a matter, however, which was being very rapidly remedied. The larger companies accepted it as an accomplished fact, and the Railway Clearing House alternatively specified welded tanks for oil conveyance on the railways, the first tanks of this type being built in Manchester. Lastly, he wished to hear Mr. Wall's views on overhead welding and any information on that subject he might have.

Mr. D. Adamson thought that a point to bear in mind when bringing up the question of riveted joints *versus* electric welded joints and seams, was that the former had been developed after many years' practical experience, whereas the latter was a comparatively new method. It was certain that riveted joints slipped at a very low percentage of their ultimate strength, frequently causing leakage. When new boilers were constructed it was possible to calculate the strength of the seams, but the calculations were arrived at after the event, and it was generally accepted that the factor of safety should be something in the neighbourhood of 4 or 5. There was no necessity for this, but no doubt it was found desirable, and these thicknesses of plates gave the results required. It was probably desirable not to reduce the thickness of plates for reasons of stiffness, and that particular feature of thickness would enable electric welding to be adopted generally.

He wished to caution people against using electric welding where it was subject to severe bending or shock. These two particular difficulties arose in a very serious degree in the hull of a ship. More confidence in the method was necessary before it could be used for internal pressures, where failure would be disastrous to life and property. The American Society of Mechanical Engineers were giving very considerable attention to the application of electric welding to boiler construction. Although in America they had not had the lengthy experience of boiler construction we had in this country, they had developed a code which had proved very useful to the American Board of Trade and which he thought was worthy of careful attention. The author had not said much about the various electrodes, and although he gave a warning against using bare wire, and one speaker suggested that various kinds of electrodes should be kept in stock with the idea of using them for various types of welds, a little guidance on this point would be very helpful. He believed that the rapid adoption of electric welding in preference to acetylene welding was due to the greater ease with which men could be trained to do electric welding satisfactorily. In one concern which, for trade union reasons, had had to discard the use of acetylene welders during the war, electric welding had been adopted because they realised that to train new men would take years, but by adopting electric welding the work could be carried on with very little delay. It was the first time in a paper before the Institution that the difficulties raised by trade unions in the introduction of a new method had been referred to specifically, and he thanked the author, as an impartial witness, for making this reference. Although this prejudice perhaps was only natural, it did not tend to rapid progress in a new method.

Mr. Roberts said he agreed with the author on all points except that of his condemnation of resistance welding. This method was used a great deal at Messrs. Vickers' works for spot welding fans for motors. Although these were under great centrifugal forces, they were simply fastened by two or four spots, according to the size of the fan. A number of tests had been taken on spot welds, and it was found that the weld was quite homogeneous. It was certain that electric welding was the best for ship construction, as in spot welding the system of lapping could not be dispensed with, and it was in that way that so much weight could be saved in electric welding. He had great confidence in the strength of welds as he had had many cut open and micro-photographed and found to be sound, the tensile tests without exception being very high (28 tons per square inch for mild steel). He could mention the case of an American all-welded ship which was crushed in between a quay and another vessel, to the extent of 18 in., without springing a leak. By some means it was straightened out again, but the welds remained quite sound and there was no leaking shown at all.

He did not think it advisable to have things acetylene cut which had to be welded afterwards, as the acetylene flame seemed to have some effect on the metal for a short distance and this was bound to affect the strength of the weld. He thought the lack of confidence in the strength of welds for shock was due to the slipshod manner in which a great deal of welding was done. Provided the weld was done with the correct electrode by a really reliable man, every confidence could be placed in it. It was necessary to deposit metal as nearly like the work to be welded as possible and giving the same characteristics. This had been done by the Quasi-Arc Company, whose welds, when tested by Lloyd's, stood 200,000 alternating stresses before they broke, and then the fracture was outside the weld.

Mr. Boswell agreed that they were much indebted to the author for his reference to the difficulties raised by the trade unions. A great deal of the success of welding depended on the human element, and had it been possible the pioneers of welding should have eliminated, right from the beginning, the so-called experts, who scamped the work and consequently spoilt everybody's confidence in electric welding. With regard to the training of welders, the actual job did not take very long to learn. During the war girls had been trained to do this work in two days. He wished to ask whether electric welding was affected by wet weather, as in riveting it was necessary to wait until the joints and seems had dried before proceeding with the work.

Mr. Burslon stated that electric welding could be applied equally well to cast-iron as to cast-steel work. With regard to alternating stresses on steel bars electrically welded he could mention the case of a heavy tractor which had been in service for a long time when the front axle broke across the centre. This axle had been electrically welded and was working very satisfactorily, the tractor carrying loads of 8 tons or 10 tons over rough cobbled roads daily.

Mr. Wall, in reply, said in electric welding it was very easy to scamp both in output and actual quality. With regard to elasticity, he did not think there was any difference between the welded ship and the riveted ship, up to the point where the riveted joint really slipped, as distinct from holding and moving under stress and strain. Both welded joint and the riveted joint behaved in exactly the same way. He did not think mild steel was as perfect as it was made out to be, as he had seen several plates sent into the yard which proved to be extremely brittle, although they had only been through the normal process. With regard to the reduction of scantlings, that was a very vexed question. It was impossible to reduce the unsupported area or the thickness of plating indefinitely; the stiffeners necessary had to be considered, and in that connection welding was much easier and cheaper than riveting.

It was well known that it had been found from experiments by Mr. Stromeyer and others that the strains in ships were not as great as shown by the standard method of calculation. It was inadvisable to depend entirely on calculations, rather a combination between practice and calculations should be made, though the latter were undoubtedly useful in moving from one point to another if the law was known.

Butt joints were still used in warships, although lap joints were thought best in modern practice, but strapping was used where special strength was needed. It was possible to build and run ships successfully with very much smaller scantlings than would be allowed in the ordinary way by Lloyd's Register. He thought everybody agreed that it was necessary to employ an efficient welder and good materials to ensure a satisfactory weld. Men must have a certain amount of training for welding, but a long period, say of three years, was quite unnecessary. It had

been suggested that men with no aptitude for this work should not be retained, but he thought enough had already been said about trade unions.

With regard to voltage, 60 volts were frequently used, and gave perfectly satisfactory results. He did not quite understand the point about varying the electrode. He presumed Mr. Strawson meant various sizes and types of electrode were used for different kinds of material and the amperage correspondingly altered for different masses of structure. After being cut by acetylene flame the metal was affected some distance in and was no good for fastening good electric welding to. Bare wire welding was rather looked upon as retrograde, and classed with oxy-acetylene welding. Flux-covered electrodes had made great advances, and had it not been for these it would not have been possible to construct the Fullagar. With regard to overhead welding, that could be done with a good flux-covered electrode, although a good deal was bound to drop down. One welder had suggested fixing an electro-magnet over the plate, but that was not much use for molten metal.

He had made a number of shock tests on welds, and though these were fairly severe and eventually bent the plate, the weld did not break. In a V butt weld, if the plate was to be bent so that the weld was on the outside of the joint, that would cause very severe strains, and it would be necessary to re-inforce the weld in some way. The case of a ship being crushed without springing a leak was very interesting. In his own experiments, he had found that electric welding really withstood alternating stresses much better than he anticipated. With regard to the question as to how far under the lap the welding went, that was very difficult to express as an actual measurement, but it was not very far. The main point was to get homogeneity of the structure between the weld and the plate, although the depth of the weld was certainly an advantage. Wet weather had the same effect on welding as on riveting, and the only way was to do as much of this work as possible in the shops.

INDUSTRIAL NOTES.

THE ballot of the workers in the shipbuilding industry on the employers' proposal for withdrawing the 26*s.* 6*d.* weekly war bonus in two instalments of 16*s.* 6*d.* and 10*s.*, was officially declared on Wednesday, the figures being: against acceptance, 113,547; for acceptance, 11,062, or a majority against of 102,485. The membership of the shipbuilding unions being, in round numbers, 350,000, it will be seen that about one-third of the men took the trouble to vote. The employers adhere to their decision to withdraw the war bonus at the rate of 16*s.* 6*d.* on the 15th inst.; they will intimate later the date on which the 10*s.* will be withdrawn, since the unions have not agreed to discuss the point with them.

The lock-out notices to workers in the engineering trades referred to in our last issue state the following: "The members of the Amalgamated Engineering Union having by ballot refused to accept the memorandum of agreement arrived at in conference on November 17 and 18, 1921, which was jointly recommended by the Federation and by the Executive Council and the National and Divisional Organisers of the union for acceptance by their constituent bodies, and which memorandum provides for the maintenance of the right of the employers to exercise managerial functions in their establishments, the Federation have resolved that as from Saturday, March 11, 1922, it is not possible for federated employers to give employment to members of the union in view of the situation created by their ballot."

At the same time, the secretary of the Engineering and National Employers' Federation addressed a letter to the Amalgamated Engineering Union in which he impresses upon the union the gravity of the situation which has arisen owing to the members having thought fit to call in question a basic principle upon which industry is conducted. The secretary adds: "The employers feel that in view of the fundamental alterations which the ballot has brought forward there is no alternative open to them but to face the situation, and in the national interest to place the industry on a sound economic basis, and accordingly the relations between the employers and their workpeople, the working conditions and the wages will require to be brought under review."

Meetings between the Federation and the union are taking place.

A contributor to the *Yorkshire Post* says that the lowest price at which good, large tramp tonnage can be constructed at the present time is from 12*l.* to 13*l.* per ton deadweight, but since at such a price it is quite impossible for owners to trade tonnage and obtain even a very modest return for their investment, no orders are being placed. There is not the slightest chance of a shipowner placing an order at anything like 12*l.* per ton, and having to wait nine or ten months for delivery of his purchase. The earning power of tonnage has always been, and will continue to be, the greatest factor bearing upon the price at which tonnage shall be constructed, and no amount of argument, either on the part of shipbuilders or shipyard employees, can get over this established truth. The shipyard workers alone are not to blame for the present high cost of production of steamers, for it is well known in the trade, the said contributor adds, that the costs of ships' engines are proportionately far in excess of the costs of the hulls, namely, three times the pre-war cost. The shipyard employees, therefore, would be well advised in getting in touch without delay with their fellow men in the engineering side of the trade and persuading them to a commonsense view of their part of the business, for no matter to what extent the shipyard workers agree to a reduction, this in itself cannot result in orders again being placed. The wages of steel workers and the cost of coal must also come down. There are millions of money held by shipowners at the present time ready to be placed into new steamers, the said contributor further states, as soon as the price is at a level permitting of even a very reasonable return to the investors.

Part II of the Mining Industry Act, 1920, has lately again come into prominence. It provided for the establishment in the mining industry of Pit and District Committees and Area and National Boards, each consisting of representatives of the owners or management, and representatives of the workers in equal numbers. These bodies, among their other duties, were to formulate schemes for the adjustment of wages. It was provided in the Act that Part II should cease to have effect if at the expiration of one year it should appear that the scheme it formulated had been rendered abortive by failure, on the part of those entitled to appoint representatives to the said bodies, to avail themselves of such right. No representative having been appointed by either side, Part II lapsed. The Mining Association intimated that they did not intend to avail themselves of their right to appoint representatives. The workmen's leaders, at first, spoke entirely against this part of the Act, but later on wanted it to be acted upon. The latest phase of the situation is made clear in a letter from Mr. Lloyd George to Mr. F. Hodges, of the Miners' Federation, which was read in Parliament last week. In this letter, the Prime Minister stated: "At a time when the opposition to these provisions came from your side a member of your executive said, 'Of course, the Bill cannot be operated without the wholehearted co-operation of owners and men.' It is equally true to-day when the opposition comes from the other side, that legislation cannot convert an unwilling man into a willing one. I fear, therefore, that so long as either party is opposed to the scheme, it would be of no real value to the industry, and, in the circumstances, the Government do not feel that they would be justified in moving Parliament to keep Part II of the Act in force."

To this Mr. Hodges has replied refuting the Prime Minister's views, and adding that the Miners' Federation will do all it can to maintain peace and prosperity in the coal industry, "but the task is increased a thousandfold when it is so patent that the British Government has assumed the role of the coalowners' advocate." Mr. Hodges could not have used stronger terms had his side always been in favour of Part II of the Act, which has not been the case by any means. It is now announced that the Labour Party have decided to move in Parliament a motion to the effect "That Part II of the Mining Industry Act, 1920, shall not cease to have effect."

The General Federation of Trade Unions is issuing an appeal to trade unionists throughout the country urging upon them to take steps for securing that their unions join the federation. The appeal states the following: "The General Federation of Trade Unions was founded in January, 1899. The object was to create an organisation capable of inaugurating a policy designed to secure to the workers the power to determine the economic and social conditions under which they should live; to give financial assistance to trade unions in times of crisis; and to meet the situation created by consolidations of capital. Taking the figures at the end of 1921, the federation during the twenty-two years of its existence has received in contributions and entrance fees the sum of 1,097,293*l.*; it has paid in strike and lock-out benefit 974,886*l.*, and it has a reserve of 129,335*l.* During the whole of this period the administrative costs of the federation, including income tax, rents, rates, repairs and renovations, have totalled 88,491*l.*, an average of only 4,022*l.* per year. No other organisation can show similar results for similar administrative expenditure. . . . The membership of the federation now exceeds 1,400,000, and it includes engineers, textile workers, ironfounders and metal workers, shipwrights, woodworkers, boilermakers, boot and shoe operatives, dockers, quarrymen, tailors, compositors and labourers. There are altogether 130 societies affiliated . . ."

We read in *The Iron Age*, New York, for February 16, that an echo of the disarmament conference is heard in an order received recently by Captain F. J. Hellweg, commandant, from Secretary of the Navy Denby, to close the naval ordnance plant at Charleston and put employees on leave without pay. The order not only affects men engaged in the operation of the plant, but also those doing construction work on the gun plant. Captain Hellweg was instructed to retain only enough men for the maintenance and protection of the plant. This was engaged in manufacturing material, some of which would have been used on ships which are to be scrapped under the holiday programme. The plant, located at South Charleston, and work on which began on April 6, 1917, consists of a steelworks and three finishing units, a projectile plant, an armour plant and a gun plant. In recent months about 2,000 tons of ordnance steel were turned out daily. About 2,200 men were employed, including nearly 1,000 on construction work. The estimated monthly pay roll was 300,000 dols.

The same journal adds that the Government's curtailment in naval construction work has resulted in 1,000 men being laid off at the Fore River Works, Bethlehem Shipbuilding Corporation, Quincy, Mass., leaving 1,800 men at work there, contrasted with 6,500 a year ago and 18,000 during the war. Work on the super dreadnought Massachusetts and the battle cruiser Lexington has been suspended. The former is 11 per cent. completed and the latter 35 per cent. Work on two scout cruisers and 16 submarines has not been discontinued.

It would be interesting to have further data in regard to these submarines.

The same American journal gives interesting particulars concerning a recent journey made by Mr. H. J. Freyn, president of Messrs. Freyn, Brassert and Co., Chicago, in Great Britain and on the Continent. With reference to Germany, he states that the German steel industry is very busy, and many changes are apparent. Plants are working day and night on three 8-hour shifts. It is noticeable that there is small difference in the wages between skilled and unskilled labour. Each plant in Germany has a Heat Department, called "Wärmestelle," and in one case an expenditure of 10,000,000 marks resulted in the saving of 40,000,000 marks. Electric locomotives in plants and waste heat boilers are numerous, gas engines are combined with waste heat boilers. One German blast furnace had averaged 700 tons per day, and on some days made as high as 811 tons and 844 tons. German steel practice was turning gradually more to open-hearth as compared with basic Bessemer.

It is expected that the lock-out in Denmark, to which we referred in a former issue, will be of long duration. The men in the Copenhagen building trades have voted heavily against the compromise proposals of the public mediator. It is being pointed out with much emphasis that the losses and other undesirable but unavoidable consequences of the conflict will be out of all proportion to what the men can gain even if they eventually should win. The main points in the conflict are the 8-hour day and pay for overtime. The mediator's proposal hardly affects the former point, at least not to an extent of great practical importance, and as far as overtime pay is concerned, it brings the present Danish rate, which is about double as high as in other countries, down to a level more in harmony with the rate paid in the latter. Either the leaders do not seem to have realised the due proportions of the position—they have in any case not guided or led their men as if they had—or they have simply allowed the responsibility to pass from themselves to the men.

HYDRAULIC POWER IN STYRIA.—The construction of large hydroelectric power stations in Styria utilising more especially, for the present, the Rivers Enns and Mur, for which complete plans have been prepared, is likely to call forth an important chemical industry. The country is greatly in need of artificial manure and there is a large market for nitrogen products. Extensive bauxite deposits are available, also important magnesite deposits.

NON-MAGNETIC CAST-IRON.—A special form of cast-iron which has a magnetic permeability practically as low as brass and an electrical resistance very much higher than that of ordinary cast-iron has been introduced by Messrs. Ferranti, Limited, of 180, Fleet-street, E.C. 4, and Hollinwood, Lancashire. It has been given the name "No-Mag." The material should be of value for resistance grids and for use in situations in which eddy currents would give trouble if ordinary cast-iron were used. The magnetic permeability is 1·03, as compared with 330 for ordinary cast-iron and 1 for brass, while the specific resistance in micro-ohms per centimetre cube is 140 as compared with 95 for ordinary cast-iron and 7·5 for brass.

THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM.

THE industrial depression from which the country is suffering at the present time makes it all the more important that British manufacturers should endeavour to secure what orders are being placed, and it is to be hoped that the British Industries Fair which was opened simultaneously last Monday in London and Birmingham may serve a useful purpose in stimulating trade. As a self-supporting enterprise organised by the Department of Overseas Trade primarily to bring foreign purchasers into touch with the manufacturers of Great Britain and the Dominions, it differs entirely in character from the usual exhibitions where space can be taken by anyone who will rent it, and where the object of the promoters is gained if a sufficient number of the general public will pay for admission. The general public is not admitted at all to the Fair, which is reserved exclusively for potential buyers. Such, of course, are welcome, and can secure admission on presentation of their trade card. Everything possible is done to attract probable purchasers, the department having, it is stated, issued about a quarter of a million invitations, 50,000 having been sent to buyers in all parts of the world. The state of the exchanges makes purchasing difficult for foreign buyers, and the prevailing tightness of money renders it impossible for many manufacturers to grant the extended terms of credit which are absolutely necessary if the impoverished nations are to buy at all. To meet the latter difficulty the Government has made arrangements to grant special credit facilities for the export trade under the Trade Facilities Act recently passed. Under the new regulations the scheme is applicable to every country in the world excepting Russia, and also excepting India, Ceylon and the Straits Settlements, where the ordinary banking facilities are adequate. The British exporter can now get his customers' bills guaranteed by the department up to their full face value, so that they are regarded as first-class bills in the discount market. General credits, which are not limited to the financing of any particular transaction, are also granted by the department, so that an exporter can enter into transactions abroad up to the amount of his credit, without the delay and inconvenience which the sanctioning of every piece of individual business would cause. The scheme is designed not to finance goods shipped on consignment nor made for stock, but to facilitate actual sales abroad, and all exporters should make themselves familiar with the regulations under which assistance will be granted them. Needless to say, the Department of Overseas Trade has arranged that full particulars on the subject are available at their Information Bureau at the Fair.

The Birmingham Fair is held this year, as on previous occasions, in the Castle Bromwich Aerodrome Buildings, which could hardly be surpassed for an undertaking of the kind. The local organisation has been carried out by a joint committee of the Birmingham City Council and the Chamber of Commerce, and the result is highly creditable to every one concerned. The systematic way in which the exhibits are grouped, and the really excellent catalogue are much to be commended, while practically not a stand was incomplete at the time of opening. The majority of the exhibits are representative of the typical Birmingham trades, comprising domestic hardware of innumerable kinds, and brass, copper and sheet metal goods generally. So far as these are concerned, the foreign visitor would get a fair idea of British manufactures, but as regards machinery in general the same statement cannot be made. This is regrettable, for the Birmingham Fair is the only one to which machinery is admitted, and a visitor might go away under the impression that such things as boilers, steam turbines, locomotives, textile machinery and many other engineering productions were not made in these islands at all. At such a Fair it would surely be a good thing to try to have some method of representing our leading engineering products, even if only by photographs. Machine tools are almost entirely absent, and motor cars are completely so, although in both cases these are local manufactures of importance. Nevertheless, in spite of the absence of whole branches of engineering exhibits, it must be mentioned that the mechanical section of the Fair is more varied and interesting than on either of the two former occasions. The depression in trade has no doubt caused many firms to consider whether it was not worth while to take part in an organised effort to stimulate export sales.

Gas and oil engines of various sizes and types are shown by Messrs. Crossley Brothers, Limited, Openshaw, Manchester. The National Gas Engine Company, Limited, Ashton-under-Lyne, Messrs. Tangyes, Limited, Birmingham, and Messrs. Petters, Limited, of Yeovil. The first three firms also show producer plants. One of Messrs. Crossley's horizontal gas engines is fitted with a very neat and simple device by which the admission of compressed

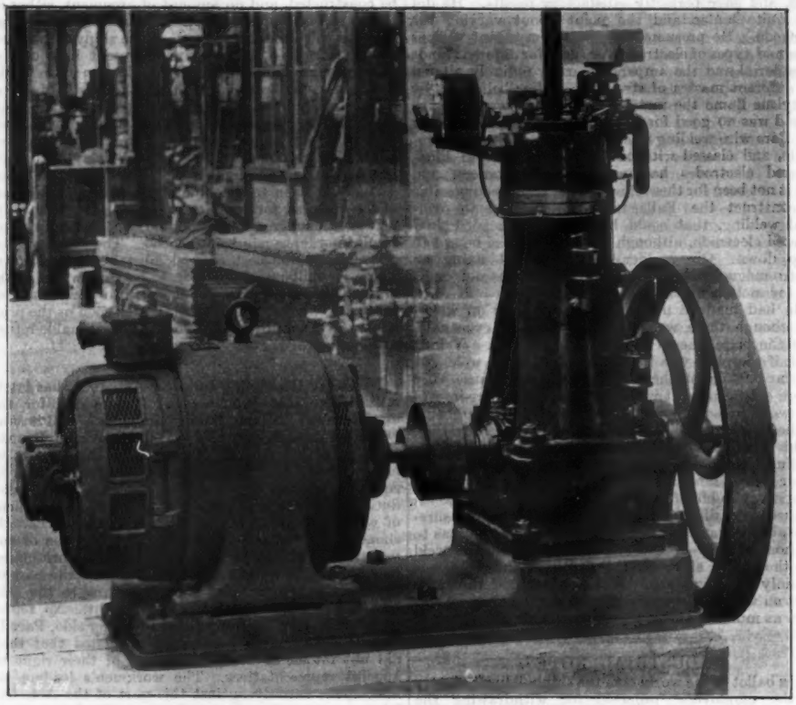


FIG. 1. VERTICAL CRUDE OIL ENGINE AND 3-KW. DYNAMO; THE NATIONAL GAS ENGINE COMPANY, LIMITED, ASHTON-UNDER-LYNE.

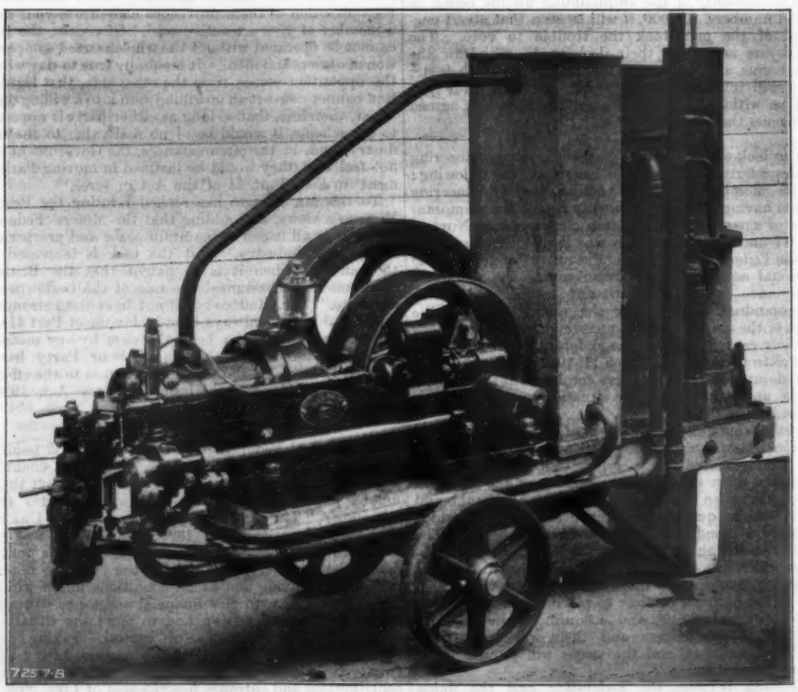


FIG. 2. PORTABLE SUCTION GAS PLANT AND ENGINE; THE NATIONAL GAS ENGINE COMPANY, LIMITED, ASHTON-UNDER-LYNE.

air for starting is automatically controlled by a cam on the layshaft, instead of being dependent upon the manipulation of a valve by the operator. Messrs. Crossley Brothers also exhibit one of their high compression cold-starting crude oil engines, a type which has shown an extremely high economy on test. Two of the smaller engines shown by the National Gas Engine Company, Limited, are illustrated in Figs. 1 and 2, opposite. The first is of the vertical type, for house lighting and similar purposes. It drives a 3-kw. dynamo, the armature spindle of which is coupled direct to the crankshaft. The cylinder is 5-in. bore by 6 in. stroke, and the engine develops 6 b.h.p. at 600 r.p.m. The method of governing is very neat, a tapered distance piece moved by the governor regulating the amount of lift of an automatic spring-controlled suction valve on the inlet. The engine will work on town's gas, petrol or paraffin, and is shown running on the former in the exhibition. The other plant, illustrated in Fig. 2, is interesting as being a very small self-contained portable suction gas plant, operated with charcoal. It was originally designed for the South African market where the price of paraffin and petrol are very high, and where the farmer can make his own charcoal. The engine has a cylinder 4½ in. bore by 8 in. stroke, and develops about 2½ b.h.p. at 350 r.p.m. It consumes about 1½ lb. of charcoal per brake horse-power hour, and will run about 3 hours on a single charge of the hopper. The generator is a cast-iron shell without brick lining. All steam required for the generator is raised from the grate, so that there are no complicated pipes in the system. The gas from the producer passes up through the scrubber, which is filled with coke or broken bricks, and thence to the engine. The whole arrangement is simple in the extreme, and the weight complete is less than 10 cwt., including the trolley on which the plant stands. The example exhibited at the Fair is working with charcoal gas.

A very interesting exhibit is that of the Metal Colouring Company, 59, Cambridge-street, Birmingham. This company is working a patent process for putting a colour finish on metal articles. The process consists in immersing the article in a bath of boiling strong caustic soda solution, the article at first forming the cathode of an electric circuit. It is immediately de-oxidised and cleaned by this treatment, and the current is then reversed, with the result that the article, if of steel, becomes covered with a firmly adherent coating of magnetic oxide, Fe_3O_4, which gives it the handsome bluish-black appearance of a rifle-barrel. We understand that the usual method of treating a gun-barrel to get the colour, involves about 8 hours' labour and occupies about a week. The new process gives a final result identical both as regards the nature and the appearance of the colouring, in about 20 minutes. No preliminary cleaning of the articles is necessary, and when they are removed from the vat they are merely washed with water. Pliers, monkey-wrenches and other things were being treated on the stand, and did not have to be taken apart for the process. In addition to steel, cast-iron, brass, &c., can be given a coat of colour, and if the treatment is continued only for a very short time a very beautiful iridescent coating is formed on a previously-polished surface. Some hammered wrought iron foliage had been given the autumnal tints of Nature with lifelike fidelity.

The Tangent Tool Engineering Company, Limited, of Keynsham, Somerset, have several novelties on their stand in addition to their rotary shears for cutting corrugated iron and other tools which we have noticed on previous occasions. Figs. 3 to 7, on the preceding page, show the latest designs of their rotary shears. The machine illustrated, although only weighing 15 cwt., will cut ¼-in. plates of any length or width at the rate of 15 ft. per minute, and will cut thinner plates at a proportionately higher speed. A swinging pointer facilitates the accurate starting of the cut. The upper cutter of the pair is the idle one and is set down to suit the thickness of the plate by the hand wheel at the top. The lever at the back of the machine operates an eccentric which serves to raise the upper cutter from its work, should it be desired to stop the cut at any point. An automatic trip can be fitted if desired. Fig. 8 represents a bending press for straightening work. The work is laid on a couple of supports and when the lever is pulled down by hand, a ram descends on to the work between the supports. The hydraulic magnification of the pull, combined with the leverage, gives a multiplication of 100 to 1 of the force exerted by the operator. We reproduced a sectional drawing, showing the internal arrangements of the press, in our issue of September 16 last, on page 416, so it will now suffice to mention that though the action is hydraulic, there are no external pressure joints to leak, nor are there any pipes or valves. Machines of the same type are shown by the Tangent Tool Company, fitted as angle croppers, punchers, &c. The angle cropper will easily cut off a 1¼-in. by 1¼-in. by ¼-in. angle with one pull on the lever, and the punch will put a ½-in. hole through ⅝-in. steel plate, also with one stroke. One machine on the stand was shown

FIG. 3.

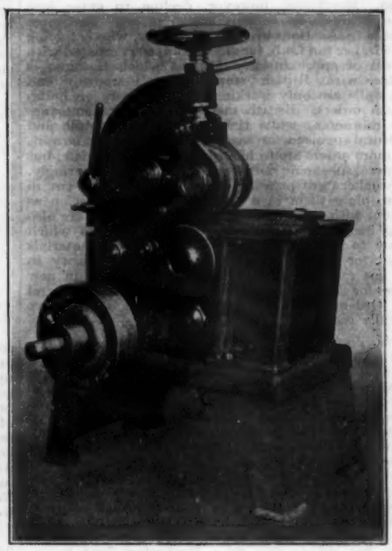


FIG. 4.

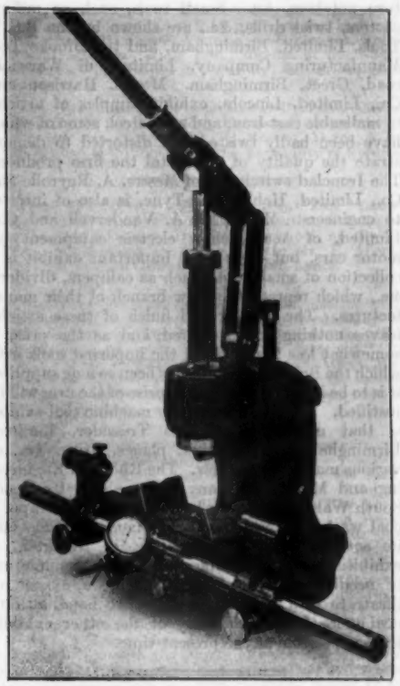
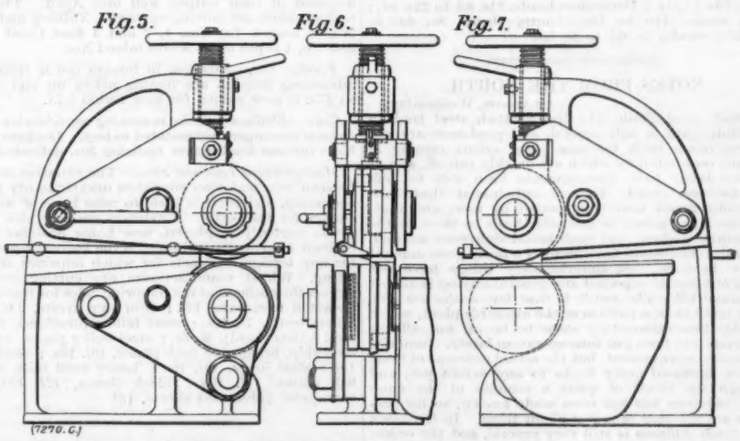


FIG. 8. BENDING PRESS; THE TANGENT TOOL ENGINEERING COMPANY, LIMITED, KEYNSHAM, SOMERSET.



FIGS. 3 TO 7. ROTARY SHEARS; THE TANGENT TOOL ENGINEERING COMPANY, LIMITED, KEYNSHAM, SOMERSET.

fitted with tools for punching and striking small aluminium medals at one stroke from the plain sheet. These were almost exactly the size and thickness of a sixpence, and the lettering was stamped well and clearly. By a jerk on the end of the lever, the operator can exert a pressure of as much as 10 tons on the tool. Other types of machines made by this company we hope to illustrate at a later date.

Visitors to the Birmingham Fair should not fail to note the range of weighing and testing machines made by Messrs. W. T. Avery and Co., Limited, of Birmingham, most of which we have illustrated at one time or another. Messrs. Taylor and Challen, Limited, of the same city also have an imposing collection of punching and drawing presses, armature notchers, &c. Small tools, such as milling cutters, twist drills, &c., are shown by the B.S.A. Tools, Limited, Birmingham, and the Brooke Tool Manufacturing Company, Limited, of Warwick-road, Greet, Birmingham. Messrs. Harrison and Co., Limited, Lincoln, exhibit samples of articles in malleable cast-iron, and semi-steel, some of which have been badly twisted and distorted to demonstrate the quality of the metal the firm produces. The Ironclad switchgear of Messrs. A. Reyrolle and Co., Limited, Hebburn-on-Tyne, is also of interest to engineers. Messrs. C. A. Vandervell and Co., Limited, of Acton, show electric equipment for motor cars, but their most important exhibit is a collection of small tools, such as callipers, dividers, &c., which represents a new branch of their manufactures. The quality and finish of these articles leaves nothing to be desired, and as the price is somewhat less than that of the imported tools with which the British mechanic has been so long supplied, it is to be hoped that the enterprise of the firm will be justified. Practically the only machine tool exhibit is that of Messrs. Charles Tressider, Limited, Birmingham, where lathes, planes, drills, &c., of various makes are on view. The Rhondda Engineering and Mining Company, Limited, of Bridgend, South Wales, show their latest design of "Draper" coal washer, as well as a glass model to illustrate its action. Mr. Edward White, of Redditch, is exhibiting several machines used in the manufacture of needles and fish hooks, which we expect to illustrate in a future issue, and we hope also to deal more fully with many of the other exhibits than is possible at the present time.

X-RAY EXAMINATION OF TEXTILES.—X-rays could obviously render useful service in the control of textile operations, especially in the manufacture of pneumatic motor tyres, where so much depends upon the durability, design and properties of the canvas, if textile fibres were not so pervious to the rays. To give distinct radiographs the yarn or canvas has to be impregnated or pasted with materials of high atomic weight which absorb the rays, and this impregnation is apt to deteriorate the fibre mechanically. Experimenting in the Dunlop Rubber Company laboratories with various salts of thorium, uranium, mercury, bismuth, &c., R. Truesdale and C. Hayes found that lead chromate reduced the tensile strengths of the fibres least. They dissolve litharge in acetic acid adding glycerin and glue, soak the yarn in this solution and then add a hot solution of potassium dichromate to the bath, so that lead chromate is precipitated within the fibre. After this preparation the contraction and elongation of the warp and weft, and the changes in structure and in strength, which a canvas undergoes when soaked in rubber solution or "frictioned or topped" with it can be studied, and the pattern will show how the canvas should be woven to remain square and strong.

A LARGE DRY DOCK IN NORWAY.—An interesting dry dock, built on a site which has had to be to a great extent blasted in solid rock, is approaching completion at Kaldnäs, Norway, for the Kaldnäs Engineering Company. Altogether 52,000 cub. m. (1,836,400 cub. ft.) of rock and earth have been removed for the dock itself, and outside the dock some 25,000 cub. m. (883,000 cub. ft.). There are channels at both sides of the dock, sloping towards the pump well. The floor slopes from the keel blocks towards the side channels. The pumping machinery has been supplied by the Ludwigsbergs Company, Stockholm, and consists of two 600-mm. (23·6-in.) and one 250-mm. (9·8-in.) centrifugal pumps, worked by 125-h.p. and 20-h.p. electric motors. Vessels will be supported on keel and bilge blocks; the former are placed 4 ft. apart; they are about 4 ft. high and consist of reinforced concrete blocks, for a height of 2 ft., with oak above. The dimensions of the dock are as follows: Clear length inside dock gates, 481 ft.; breadth at top, 80 ft.; breadth at the lowest step, 72 ft.; breadth at the floor, 70 ft.; depth above the keel blocks at ordinary water level, 22 ft. Railway tracks run along the side of the dock, and are connected with the railway system of the company.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Recent signs of improvement are very slow in materialising in every section of the iron and steel trades. Increased activity at individual firms is offset by a further contraction in new business at others. The total of unemployed tends in an upward rather than a downward direction. The aggregate of 50,000 workers now idle in the local staple industries is only comparable with the results which accrued from former coal stoppages. One of the busiest sections so far as purchases are concerned is that devoted to scrap. One of Sheffield's largest scrap firms is concluding arrangements to take over a Government dockyard for the dismantling of ships, and another has just purchased an additional number of warships from the British Admiralty. The current demand for iron and steel scrap on home account is not large, though it tends to increase. Merchants, however, decline to enter into forward business at current slump prices. The most profitable transactions are with Germany, who is paying about 55*s.* per ton f.o.b. for steel scrap, as compared with the level of approximately 35*s.* at which business is available with British steelmakers. Foundries and rolling mills are only working intermittently on hand-to-mouth orders. British mercantile requirements are at the minimum, while the needs of automobile and agricultural engineers are easily met from current output. A few more orders are to hand for railway materials, but as a general rule home railways are buying very sparingly. Spring-makers are pressing for a further wages cut in order to place them in a more favourable position as compared with competitive districts. Collieries are also holding back owing to the alleged high prices which continue to rule in wagon building and in materials required for colliery repairs. A marked disparity in prices has resulted from increased competition in new business for files, saws, pincers and other classes of hand tools. Orders from America for special steels have practically ceased.

South Yorkshire Coal Trade.—Despite easier conditions in steam and gas fuel, the price of best quality house coal is maintained. This is perhaps the busiest section of the market. Merchants have substantial orders on their books, and expect to be fully employed for some weeks to come. The adjustment of steam coal rates to meet the depressed condition of the manufacturing trades has resulted in the receipt of an increased number of inquiries, and the outlook is considered more hopeful. The export of best steams is certainly on an improved scale. Cobbles and nuts show considerable weakness, but slacks are a rather firmer market. Quotations:—Best branch handpicked, 38*s.* to 39*s.*; Barnsley best Silkstone, 36*s.* to 37*s.*; Derbyshire best brights, 34*s.* 6*d.* to 35*s.* 6*d.*; Derbyshire best house, 33*s.* 6*d.* to 34*s.* 6*d.*; Derbyshire best large nuts, 28*s.* to 30*s.*; Derbyshire small nuts, 17*s.* to 19*s.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*; rough slacks, 14*s.* to 15*s.*; nutty slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; smalls, 2*s.* 6*d.* to 6*s.* 6*d.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the Scottish steel trade a very dull state is still general, and producers are not booking much fresh business. The orders coming in continue on small lines which are quickly run off, and at no time lately have managements been able to look any distance ahead. It was anticipated that such conditions would have disappeared by now, and that, with the home prices on a similar basis to those of the Continental makers, and with better deliveries assured, the local works would have secured a fairly good amount of new business, but unfortunately things have not turned out just as expected and general buying is almost at a standstill. The result is that few works are able to run more than a portion of the available plant, which is a far from satisfactory state to be in, but all the same more has been put into operation lately. Inquiries show some improvement, but the actual outcome of these has not increased order books to any extent yet, and although the result of quite a number of the more recent inquiries has not been made known, so far producers are not over sanguine about them. In the black sheet trade dullness is still very general, and the orders being fixed up do not amount to a very heavy tonnage, and these are mostly on export account. Galvanised sheets are the turn quieter, but with stocks of all kinds of sheets abroad gradually getting low an improved demand is being looked for at no very distant date. Prices all round are steady.

Malleable Iron Trade.—In the West of Scotland malleable iron works there is very little doing, and bold bids have lately been made in order to secure some of the export trade. There is, however, very little of that on offer, but for what there is the local makers are cutting very keenly and as low as 11*l.* per ton has been named for a tolerably good specification.

Scottish Pig-Iron Trade.—There has been little change in the position of Scottish pig-iron over the week, but, if anything, a slightly better tone is in existence. Home business is very dull yet and not much iron is in demand, but on the other hand there has been rather a better inquiry from abroad, and some parcels have been fixed up. Prices are steady, but where a good order is on offer ironmasters are prepared to give a favourable quotation. Hematite iron is very slow on account of the dullness in the steel works.

Scottish Shipbuilding.—The output of new tonnage from the shipbuilding yards in Scotland during the month of February was exceedingly poor, and consisted of 8 vessels totalling 24,448 tons in all. The whole output was from Clyde yards with the exception of one vessel, the Uribitarte, 3,850 tons, launched by the Burntisland Shipbuilding Company, Limited, for Bilbao owners. The past month's record compares badly with the corresponding month of last year when the total was over 82,000 tons, and it is also a long way below the average February output. It is, in fact, the smallest for many years. It only accentuates the fact of the scarcity of new contracts during the past year. That order books are so bare is a very serious thing for the general trade of Glasgow and the West of Scotland, but so long as the cost of new tonnage remains so high owners cannot be expected to come into the market. Negotiations now in progress with regard to wages and conditions of employment in the shipyards may result in lower costs of production, and if so we may hear of the placing of some new orders before long. During the past month, Messrs. Lithgows, Limited, Port Glasgow, secured an order for a passenger steamer, 280 ft. in length, for Australian owners, and Messrs. Fleming and Ferguson, Paisley, booked a contract for a small dredger and two barges for the Roumanian port of Sulina, on the Danube. One or two other contracts are being spoken about, but nothing has yet been given out officially.

The total output from the different districts in Scotland for the first two months of this year is as follows:—

	Vessels.	Tons.
The Clyde	17	79,212
The Forth	1	3,850
The Tay	1	800
The Dee and Moray Firth ...	4	110
Total	23	83,972

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is a steady firm feeling in Cleveland pig-iron so far as the better qualities are concerned, values of which show a rather marked upward tendency, home and foreign demand being fairly good, and supply none too plentiful. Mottled and white, however, continue quite abundant, and difficult to dispose of. Producers are under no obligation as to what they may charge for these lower grade irons, and they are keen sellers of mottled and white at 75*s.*, and even less. As regards the other qualities producers' mixed minimum rates on both home and export account still stand:—No. 1 and siliceous iron, 95*s.*; No. 3 G.M.B., 90*s.*; No. 4 foundry, 87*s.* 6*d.*; and No. 4 forge, 82*s.* 6*d.*

Hematite.—Keen competition for contracts is no longer noticeable in the hematite department. On the contrary, makers are now well sold, several firms being unable to entertain offers for March delivery, and some having disposed of their output well into April. The result is that values are moving upward. Nothing under 100*s.* is now named for Nos. 1, 2 and 3 East Coast brands, and No. 1 is put at 1*s.* above mixed Nos.

Foreign Ore.—Business in foreign ore is trifling, but advancing freights are forcing prices up and 26*s.* 6*d.* to 27*s.* is now named for best Rubio c.i.f.

Coke.—Stiffness in coke is causing considerable anxiety to local consumers necessitated to buy. Durham average blast furnace kind is now realising 30*s.* delivered.

Manufactured Iron and Steel.—The situation as regards finished iron and steel continues unsatisfactory and discouraging, and there is little to raise hope of any early change for the better. Producers are only able to keep works partially employed, new home business is most difficult to arrange, and there is the keenest competition for any foreign contracts for which inquiries are circulating. Whilst manufacturers are cutting prices for export they adhere to the following rates for home trade: Common iron bars, 12*l.*; iron ship rivets, 14*l.*; steel billets (soft), 7*l.* 10*s.*; steel billets (medium), 8*l.* 15*s.*; steel billets (hard), 9*l.* 5*s.*; steel boiler plates, 14*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 9*l.* 10*s.*; fish plates, 14*l.* 10*s.*; black sheets, 12*l.* 10*s.*; and corrugated galvanised sheets, 16*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The volume of the South Wales coal trade with India continues to expand. In the past six months 715,000 tons of coal has been exported as cargo, compared with practically nothing during the whole of 1920 and the first half of 1921. In November last the Bombay, Baroda and Central India Railway placed a contract for 150,000 tons of best Admiralty and Monmouthshire large coal, and in January another order was placed for 100,000 tons of Welsh coal, both for delivery in India over four months. The Bombay and Baroda Company is now inviting tenders for 170,000 of Welsh large coal or alternatively two-thirds large and one-third small, delivery at Bombay over the second half of this year. Tenders have to be deposited in London by Tuesday next. In view of the revival in Indian trade it is interesting to note that shipments of Welsh coal to Bombay in February amounted to 79,000 tons, compared with 65,000 tons in November last, to Karachi 30,000 tons against 5,200 tons, and Colombo 26,000 tons against 24,000 tons. In the meantime the recent improvement in market prices has been maintained and values are now from 1*s.* 6*d.* to 3*s.* per ton higher than they were at the commencement of February. Best Admiralty large is firm at 27*s.* to 27*s.* 6*d.*, seconds 26*s.* 6*d.* to 27*s.*, best Monmouthshire large 25*s.* 6*d.* to 26*s.*,

best dry large 26*s.* 6*d.* to 27*s.*, best steam smalls 20*s.* to 21*s.*, seconds 19*s.* to 20*s.*, and ordinaries 16*s.* to 18*s.* These prices are fully upheld despite the difficulties which collieries experience in regard to wagons as a result of inadequate loading accommodation at the docks and the consequent delays to trucks. Strong efforts are being made to get the coal trimmers and tippers to agree to a split shift system of working in place of the present continuous shift by which it is estimated that the capacity of the docks would be increased by 20 per cent.

Ship-Repairing Contracts Lost.—Only one contract out of six recent estimate jobs has been secured by South Wales repairers, though each vessel was already in the local docks. A couple of weeks ago the Newcastle steamer Turkestan and the Cardiff steamer Fifetown ran ashore in the Bristol Channel and sustained extensive bottom damage. In the first case some 40 plates required renewing and in the second about 80, besides frames, &c. Tenders were invited, the result of which was that the work on the Turkestan has been secured by the New Waterway Shipbuilding Company, Rotterdam, and the Fifetown by Robb and Co., of Leith. Both vessels will proceed to their repairing ports from Cardiff and Barry respectively under their own steam. Recently bottom work on the steamer Loos was secured by Immingham repairers, the Euterpe by Garston and the War Tamar by Appledore, the only work secured locally being that on the Pengelly, by the Penarth Pontoon Company.

Iron and Steel Trade.—Business in Welsh steel and tin plates remains restricted, though makers' ideas are that prices are hardening in view of the advance in pig-iron and coke prices. Tin plates are steady at 18*s.* to 19*s.*, with sellers disinclined to accept substantial orders.

CONTRACTS.—Messrs. Thompson Brothers (Bilston), Limited, Bradley Engineering Works, Bilston, Staffs., have recently completed a contract for 20-ton oil and spirit rail wagon tanks, of the "welded" type, for use on the Great Indian Peninsular Railway. These were welded throughout, and all fittings welded to the tanks.

MECHANICAL STOKERS IN SOUTH WALES.—Messrs. Ed. Bennis and Co., Limited, 28, Victoria-street, S.W. 1, have sent us particulars of the trial of a Lancashire boiler, 9 ft. by 30 ft., at the Cambrian Collieries, Limited, Clydach Vale, fitted with a Bennis sprinkler stoker and self-cleaning compressed air furnace, South Wales types. The trial was comparative between the Bennis stoker and hand-firing. The figures are as follow: Evaporation per boiler per hour, mechanical 11,900 lb., hand 6,303 lb.; evaporation per pound of coal, mechanical 8·23 lb., hand 6·42 lb.; fuel burnt per square foot of grate area, mechanical 31·45 lb., hand 22·33 lb.; thermal efficiency, mechanical 66·77 per cent., hand 53·5 per cent.; fuel costs for equal evaporation, mechanical 78, hand 100.

HYDRO-ELECTRIC ENGINEERING.—The Edinburgh Chamber of Commerce and Manufactures has addressed a letter to the chairman of the University Grants Committee, the Minister of Education, the Secretary for Scotland, and the President of the Board of Trade on the subject of the training at Edinburgh of students in hydro-electric engineering. The Chamber is of the opinion that Edinburgh is the most suitable academic centre for such instruction and training, and that the existing lectureships in hydraulics and electrical engineering at Edinburgh University and the Heriot-Watt College should be utilised as the foundation for the development of a definite and complete course in hydro-electric technics. It is also considered that an annual Government grant should be allotted for the augmentation of lecturer's salaries and for the provision of additional plant to bring existing facilities up to the requirements of such a development.

THE LATE MR. JOHN GEORGE KINGHORN.—We regret to have to announce the death, which occurred on February 17, at his residence, "Ardoch," Prospect-road, Prenton (Cheshire), of Mr. John George Kinghorn. Mr. Kinghorn was the eldest son of the late Mr. David Kinghorn, for many years managing director of the London and Glasgow Shipbuilding and Engineering Company, Limited, and a descendant of Robert Napier. He received his early education at the Glasgow High School and then entered Glasgow University, where he studied under Professor Rankine. He served his apprenticeship with Messrs. Aitken and Mansel, Whiteinch, Glasgow, and with the London and Glasgow Shipbuilding and Engineering Company, Limited; he was in both for a period of about nine years, during part of which time he was employed as ship draughtsman. He then spent one and a-half years at sea as engineer. Mr. Kinghorn then re-entered the London and Glasgow Company, and in 1874 he joined the surveying staff of Lloyd's Register as engineer and ship surveyor, Liverpool. He retired in 1884, when he established a consulting engineer and naval architect's practice, and founded the firms of Kinghorn Brothers and The Metallic Valve Company, Liverpool, for the manufacture of Kinghorn metallic valves under his patents. Mr. Kinghorn was a member of the Institution of Naval Architects, Institution of Engineers and Shipbuilders in Scotland, Liverpool Engineering Society, Royal Clyde Yacht Club, and the Hammermen of the City of Glasgow. He was a widely travelled gentleman with a multiplicity of interests and numerous friends in many parts of the world. Owing to failing health—he was in his 73rd year—he retired some time ago from active participation in business.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 3, at 8 p.m., at Caxton Hall. Lecturette, "Factory Administration," by Mr. Edward T. Elbourne. Friday, March 10, at 8 p.m., at the Caxton Hall. Paper—"Friction," by Mr. C. Hubert Plant, Associate (slides).

THE INSTITUTION OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, March 4, at 4 p.m., in the College of Technology, Manchester, Mr. J. Wood, of Wakefield, will give a paper on "Cupola Practice."

THE SURVEYORS' INSTITUTION.—Monday, March 6, at 8 p.m., in the Lecture Hall of the Institution. Paper entitled "The Analysis of Building Costs," by Mr. B. Price Davies (Fellow).

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, March 6, Informal Meeting. Discussion on "E.H.T. Cable Testing," to be opened by Mr. R. Ambrose.

THE ROYAL SOCIETY OF ARTS.—Monday, March 6, at 8 p.m.: Cantor Lecture, "The Mechanical Design of Scientific Instruments," by Professor Alan F. C. Pollard, A.M.I.E.E., F.Inst.P., Department of Optical Engineering, Imperial College of Science and Technology, South Kensington. (Lecture III.)

THE BRADFORD ENGINEERING SOCIETY.—Monday, March 6, at 7.30 p.m., Lecture in the Hall of the Bradford Technical College, by Mr. S. J. Young, B.Sc., A.M.I.M.E. (Bradford Technical College), on "The Magneto." Illustrated by lantern slides and actual examples.

THE SOCIETY OF ENGINEERS.—Monday, March 6, at 5.30 p.m., in the Apartments of the Geological Society, Burlington House, W. (entrance at the east end of the building in Piccadilly). Paper on "The Testing of Small Electrical Plant," by Dr. C. V. Drysdale, D.Sc., F.R.S.E., M.I.E.E., illustrated by lantern slides.

THE INSTITUTION OF BRITISH FOUNDRYMEN: BURNLEY SECTION.—Tuesday, March 7, at 7.15 p.m., in the Municipal College, Ormerod-road, Burnley, Mr. J. Hogg, of Burnley, will give a paper on "Melting Steel and Cast-Iron together in the Cupola."

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS, SCOTLAND.—Tuesday, March 7, at 7.30 p.m., a Special General Meeting will be held in the Rankine Hall, at 39, Elmbank-crescent, Glasgow. Discussion on paper entitled "The Economic Proportions of Cargo Ships," by Mr. W. G. Cleghorn, B.Sc.; discussion on paper entitled "Analysis of Propeller Performance," by Mr. Campbell Macmillan, B.Sc.; discussion on paper entitled "The Design of Screw Propellers and the Analysis of Trial Results," by Mr. W. J. Duncan, B.Sc.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 7, at 6 p.m. Paper to be submitted for discussion: "The Improvement of the Port of Valparaiso," by Mr. Arthur Cliffe Walsh and Mr. William Frank Stanton, B.Sc.(Eng.), Assoc.MM.Inst.C.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS, SOUTH MIDLAND CENTRE, STUDENTS' SECTION.—Tuesday, March 7, at 7.30 p.m., at the University, Edgbaston, Mr. W. P. Conly will read his paper entitled "The Measurement of Flux Density in the Air Path of a Magnetic Circuit."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Tuesday, March 7, at 3 p.m., Sir Arthur Keith, M.D., LL.D., F.R.S., M.R.I., Fullerian Professor of Physiology, R.I., on "Anthropological Problems of the British Empire: Series I.—Racial Problems in Asia and Australasia" (Lecture III); Thursday, March 9, at 3 p.m., Mr. H. Maxwell Lefroy, F.E.S., F.Z.S., on "(II) The Balance of Life in Relation to Insect Pest Control"; Saturday, March 11, at 3 p.m., Sir Ernest Rutherford, LL.D., D.Sc., F.R.S., M.R.I., Professor of Natural Philosophy, R.I., on "Radioactivity" (Lecture II).

THE ROYAL SOCIETY OF ARTS.—Wednesday, March 8, at 8 p.m.: Ordinary Meeting, "The Proper Functions of Trade Unions," by Mr. W. A. Appleton, C.B.E., Secretary to the General Federation of Trade Unions. Mr. John Murray, M.P., will preside.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, March 8, at 7.30 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C. 4. Paper by Mr. A. Hugh Seabrook, M.I.Mech.E., M.I.E.E., on "Thermal Efficiency of Small Power Stations and Methods of Comparison."

THE INSTITUTE OF METALS.—Wednesday, March 8, at 10 a.m., Annual General Meeting in the Hall of the Institution of Mechanical Engineers, Storey's Gate, S.W. 1. "Notes on the Corrosion and Protection of Condenser Tubes," by Mr. G. D. Bengough, M.A., D.Sc., Member, Investigator to the Corrosion Research Committee; paper on "The Internal Mechanism of Cold-Work and Recrystallisation in Cupro-Nickel," by Mr. Frank Adcock, M.B.E., B.Sc., Member, Teddington; paper on "The Effect of Impurities on Recrystallisation and Grain Growth," by the Research Staff of the General Electric Company, Limited (work conducted by Major C. J. Smithells, M.Sc.), and a paper on "Further Studies in Season Cracking and its Prevention: Condenser Tubes," by Mr. H. Moore, O.B.E., Ph.D., F.I.C., Member, and Mr. S. Beckinsale, B.Sc., Member, Woolwich, will be read and discussed. 7.30 for 8 p.m., Annual Dinner, Trocadero Restaurant, Piccadilly Circus, W. 1. Thursday, March 9, at 10 a.m., in the Hall of the Institution of Mechanical Engineers, Storey's Gate, S.W. 1. Paper on "The Rate of Combination of Copper and Phosphorus at Various Temperatures," by Professor C. A. Edwards, D.Sc., Member of Council, and Mr. A. J. Murphy, Student Member, Swansea; Note on "Some Cases of Failure in 'Aluminium' Alloys," by Mr. W. Rosenhain, D.Sc., F.R.S., Vice-President, Teddington; paper on "Some Mechanical Properties of the Nickel-Silvers," by Professor F. C. Thompson, D.Met., B.Sc., Member, and Mr. Edwin Whitehead, Manchester; paper on "A Further Study of the Alloys of Aluminium and Zinc," by Mr. D. Hanson, D.Sc., Member, and Marie L. V. Gayler, M.Sc., Member, Teddington; and a Note on "The Assay of Gold Bullion," by Mr. Arthur Westwood, Member, Birmingham, will be read and discussed.

THE INSTITUTE OF COST AND WORKS ACCOUNTANTS.—LONDON AND DISTRICT BRANCH.—Wednesday, March 8, at 7 p.m., at the Hall of the Institute of Chartered Patent Agents, Staple Inn Buildings, Holborn. Paper by Mr. G. H. Hale on "Costing and its Relation to Production."

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS.—Wednesday, March 8, at 2.15 p.m., at the Institution of Electrical Engineers, Victoria Embankment, Special General Meeting. At 3 p.m., discussion on "Signal Replacers," opened by a paper by Mr. B. W. Cooke (Member).

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 10, at 9 p.m., Friday Evening Discourse will be delivered by Professor T. R. Merton, D.Sc., F.R.S. The subject is "Problems in the Variability of Spectra."

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—A meeting of this Institution is to be held in the North-Western District, Blackpool, on the 25th inst. Applications are to be sent to Mr. E. Worrall, Stretford Council Offices, Old Trafford, Lancs.

INSTITUTE OF METALS.—The annual meeting of the Institute of Metals will be held on Wednesday and Thursday of next week, and the programme will be found amongst our "Notices of Meetings." The secretary, Mr. G. Shaw Scott, 36, Victoria-street, Westminster, S.W. 1, will send visitors' tickets for the meetings to those interested who may not be at present members of the Institution.

EAST OF SCOTLAND ELECTRICITY DISTRICT.—The Electricity Commissioners give notice of the provisional determination of an electricity district for the East of Scotland. This would cover the City of Edinburgh, the whole of the Counties of Midlothian and East Lothian and parts of the Counties of Linlithgow and Peebles. A map of the proposed area is available for public inspection at the Town Clerk's Office, Edinburgh, the offices of the clerks of the various counties affected, and in other public offices in the district. Any objections or representations in connection with the question of inclusion or exclusion in or from the area should be made to the Electricity Commission, Gwydyr House, Whitehall, S.W. 1, not later than July 31 next. A local inquiry in connection with the supply of electricity in the proposed district will be held in due course, and schemes for the constitution of a joint authority should be submitted by July 31 next. Notice of the date of the inquiry will be given later.

HEADMASTERS' EMPLOYMENT COMMITTEE.—This committee is composed of headmasters of public secondary schools, has offices at Howard Hotel, Norfolk-street, Strand, W.C. 2 (telephone, Central 5429), and interests itself in the problems confronting the boy of 16 and upwards who has left school and is taking his first step in professional or commercial life. Its immediate task is the finding of suitable posts for the 400 or so boys on the register. The service rendered is voluntary, both to employers and to the boys. The committee has been enabled to place 251 boys in employment during the last six months, the majority in banks and insurance offices. There remain, however, many boys of marked technical ability for whom openings in their chosen professions are few and far between. The committee is convinced that employers will find it of real benefit for boys to be introduced to them from public secondary schools, who have received a sound general education of approved standard up to the age of 16 or 18 years, and who are personally recommended by their headmasters.

HEAT-TREATMENT OF NON-FERROUS ALLOYS.—Dr. D. Hanson, of the National Physical Laboratory, lectured on the subject of "Heat Treatment of Non-Ferrous Alloys" to the members of the Birmingham Metallurgical Society at the Chamber of Commerce on the 16th ult. The lecture was illustrated with lantern slides, which included excellent micro-photographs and was devoted largely to the consideration of the phenomenon of "age hardening" of certain alloys, notably duralumin, and the new "Y" alloy recently discovered and developed at the National Physical Laboratory. Dr. Hanson reminded the audience, however, that "age hardening" was by no means restricted to aluminium alloys, but was found to occur in several directions and had many commercial applications. In the case of duralumin, "age hardening" was found on close scientific investigation, to be due to the difference in solubility of the magnesium silicide compound present in the alloy. The chairman, Mr. A. J. C. Smout, stated that Dr. Hanson had touched upon quite a new field of work, and one which undoubtedly possessed great commercial possibilities if exploited on scientific lines. He referred to several cases where non-ferrous alloys could be heat-treated advantageously.

THE NEW STREET VIADUCT AT DOVER.

CONSTRUCTED TO THE DESIGN OF MESSRS. L. G. MOUCHEL AND PARTNERS, LIMITED, ENGINEERS, WESTMINSTER.

(*For Description, see Page* 251.)

FIG. 20. SIDE VIEW OF BRIDGE OVER THE DOVER AND DEAL RAILWAY.

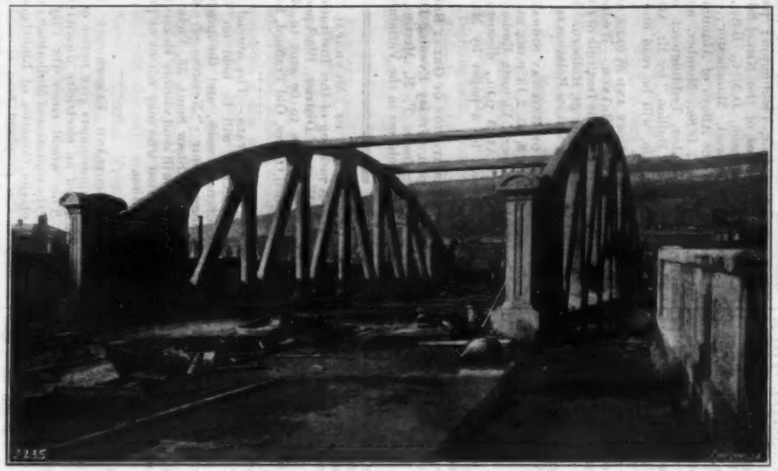


FIG. 21. DECK VIEW OF BRIDGE OVER THE DOVER AND DEAL RAILWAY.

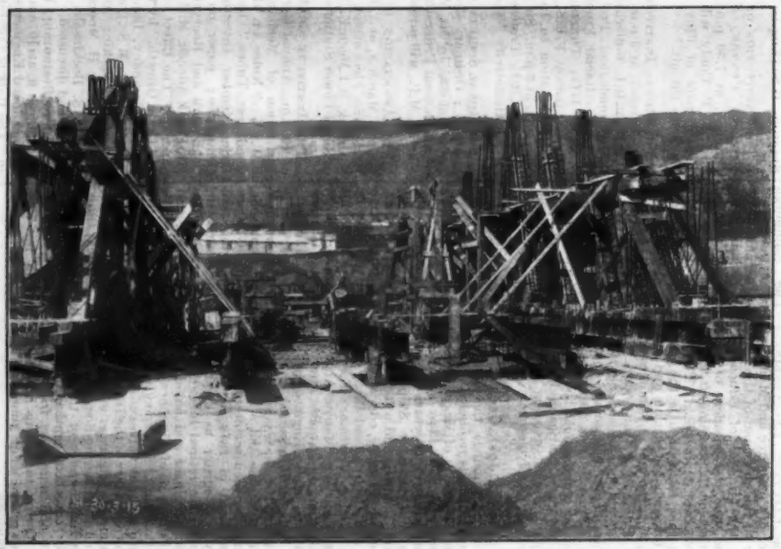


FIG. 22. BRIDGE OVER THE DOVER AND DEAL RAILWAY DURING CONSTRUCTION.

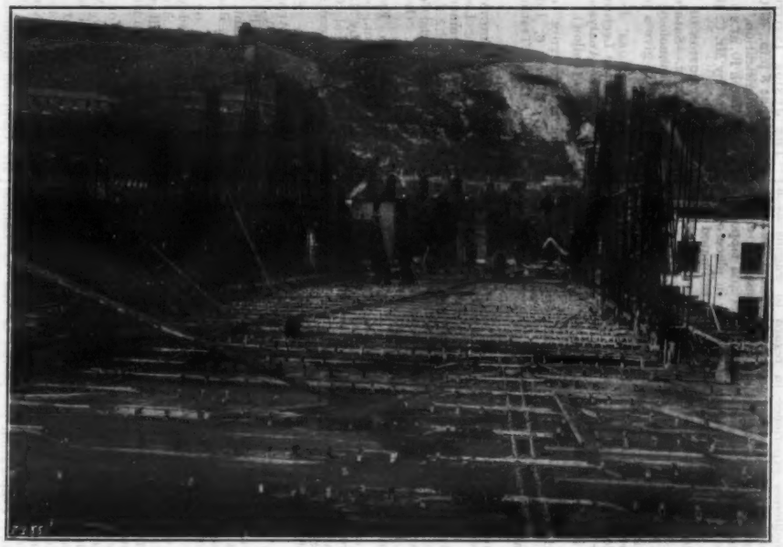


FIG. 23 BRIDGE OVER THE DRAINAGE WORKS DURING CONSTRUCTION.

ENGINEERING.

Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

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NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.

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TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.

UNITED STATES: For Subscription, New York: W. H. Wiley, 432, Fourth Avenue. For Advertisements: J. S. Allan, 30, Church-street, New York.

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ENGINEERING.

FRIDAY, MARCH 3, 1922.

THE LOSS OF THE "R. 38."

THE opinion widely held since the full accounts of the disaster to the R. 38 became available, viz., that the accident was due to the fact that the structure of the airship was insufficiently strong to withstand the stresses resulting from the operation of the controls, is fully confirmed by the report of the Accidents Investigation Sub-Committee of the Aeronautical Research Committee. As to whether or not the present report confirms the statements in the Admiralty report, briefly referred to on page 47 *ante*, to the effect that no undue risk was taken in the design and that, as regards safety, no change from previous practice was made which was not justified by experience or by comparison with German ships, we shall express no opinion, as much more information than is at present available would be required on which to fairly base a just verdict. Particulars of the vessel and of the fatal accident which occurred in its fourth trial flight have already appeared in our columns,* and as these are probably fresh in the minds of those who are interested in airship developments, we need not recapitulate them.

The report we are now considering throws much interesting light on the principles adopted in the design of the vessel, the unsoundness of which has been demonstrated with such tragic force. The fundamental error of judgment made in this design appears to have been that the calculations of the staff failed to take into account the aerodynamic forces to which the ship would be subjected in flight, and considered only the forces and moments due to the distribution of weight and buoyancy, including gas pressures. It should be borne in mind that in August, 1918, when the design was first laid out, but little information as to the magnitude of the actual aerodynamic forces on an airship was available. Some experiments on a model of the R. 29 had been made which showed a large resultant bending moment due to these forces, but as the experiments, at that time, were uncorroborated by full-scale work, and as R. 29 flew successfully, the model results were mistrusted. Previous airships made sufficiently strong to resist the forces due to weight and buoyancy had shown no distress under aerodynamic forces, and the design staff accordingly took such ships as a basis for the design of R. 38. It is clear, however, from the report we are now considering, that there was a fundamental difference between the earlier and later ships, for the maximum stresses in R. 29 (adopting the method of calculation employed in the design of R. 38) were such that the factor of safety for static loading would be about 10, whereas that for R. 38, on the same assumption, was only 4. As will be explained later, its actual value, using more reliable assumptions, was much lower than this.

The reason for the employment of this comparatively low factor of safety was, of course, that a very high performance was required in R. 38 for military reasons. A particularly high ceiling was necessary to avoid hostile aircraft so that weights had to be reduced to the minimum, and some idea of the sacrifice made to this end may be gathered from the fact that to have doubled the strength of the main longitudinals, using the same type of girder, would have involved a reduction in the disposable lift of about 4 tons and a drop in the maximum height of 2,800 ft. High speed and good manœuvring power were also important *desiderata* in the design. It is now evident that the decision to disregard the model experiments and the calculations of aerodynamic forces and moments based on first principles to which those experiments lead, was a mistaken one, and the Committee point out that an analysis of the observations taken in the course of the last flight of the R.38 fully confirms this view. While they did not accept the model results, the R.38 design staff was fully alive to the importance of obtaining corroboration or contradiction of them, and for some time prior to the trials had pressed for full-scale experiments to be carried out. Further information as to aerodynamic forces on airships has, of course, become available since August, 1918, and some of this later work is referred to in the report. In particular, we may mention that in certain full-scale experiments, reported on in February of last year, pressure-recording apparatus was fitted to the upper fin and rudder of R.32, and a limited number of observations made during flight under various conditions, including rapid movements of the controls. The present report mentions that the results were of a similar character to those obtained from pressure plotting on a model of R.32, and the Committee therefore consider that, on the whole, model experiments afford a sufficiently reliable basis for calculations. The effect, however, of reading the document is to emphasise the need for more full-scale work on airships, referred to by Sir Richard Glazebrook at the recent Air Conference and reported on page 188 *ante*.

The report makes it amply clear that during the final flight no loads in excess of those likely to occur in normal navigation were imposed upon the vessel, and that neither the constructional material nor the weather conditions at the time contributed in any way to the accident. It is mentioned, however, that the provision of specially powerful control surfaces of a new design virtually accentuated the structural weakness. These control surfaces, it will be remembered, were of a form similar to the cruiser rudder used by naval architects, and had not previously been employed on airships. Some interesting particulars of the action of this type of rudder deduced from turning trials of German battleships will be found in an article entitled "Rudder pressures and Airship R. 38," which appeared on page 651 of our last volume. They show very clearly that, in the case of a ship, a reversal of the helm is accompanied by very much larger forces than occur when the rudder is used in the ordinary way. In one case mentioned, the pressure on the rudder at 25 deg. of helm when checking a swing was three times as great as that at the same angle when producing the

* See vol. cxi, page 723; vol. cxii, pages 320, 545, 651.

swing. The corresponding ratio at 30 deg. was 3·5 and the figure then diminished as the angle increased until at 38 deg., the maximum angle, the ratio of pressures was 1·7. Such reversals of helm would be necessary in the navigation of an airship and similarly increased forces would probably be produced giving rise to high stresses which would frequently be reversed in direction. The above-mentioned article also considers the effect of the fins to the after vertical and horizontal edges of which the rudders and elevators of an airship are hinged and shows that the turning effect, and the stresses on the structure, would be considerably greater than those due to the movable control surfaces acting alone—especially at large angles. Some model experiments made at the National Physical Laboratory in which the fin was a rectangular plate measuring 8 in long by 6 in. deep, and the rudder hinged to it was 4 in. long and of the same depth, are quoted from which it appears that by the presence of the fin the lateral force is increased by 10 per cent. at 10 deg., by 28 per cent. at 20 deg., by 100 per cent. at 30 deg., and by 150 per cent. at 35 deg. These striking results appear to have considerable bearing upon the subject under discussion.

The controls of R. 38, it may be added, if not actually overbalanced, were so well balanced that but little effort was required to set them over to a large angle. Furthermore, it is stated in the conclusions that, owing to instability of the ship, large and rapid movements of the controls were necessary to keep her on her course, and the structure was not improbably weakened by the cumulative effect of reversals of stress of a magnitude approaching the failing stress. In support of this view it is mentioned that, during a previous flight, difficulty was experienced in keeping a steady height when the speed was increased to 50 knots. "Hunting," in fact, occurred through a height range of about 500 ft., and although this was largely corrected by prompt action on the part of the late Flight-Lieutenant Pritchard, it was nevertheless the cause of the buckling of certain girders amidships. It is, of course, an easy matter to be wise after the event, but it certainly seems rather surprising that the design staff should have attributed this failure to the action of the slipstream from one of the airscrews as they did. On a former occasion we expressed the opinion (see page 545, Vol. CXII), now confirmed by the Committee's report, that this buckling was significant as being the first indication of the existence of dangerous stresses in the structure. There can be no doubt that a thorough investigation at this stage would have established the fundamental weakness of the design and would thus have prevented the disaster.

Using the results of experiments on models of R.38 and R.33, in conjunction with full-scale data obtained during the last flight of the former, Professor Bairstow has estimated the stresses in the structure when the vessel was flying at 54 knots (which was the speed at the time of the accident), at an angle of pitch of 10 deg., with the elevators set to the corresponding position, and also when flying horizontally in a circle with the helm set hard over. These calculations show that when flying at 10 deg. the bending moment on the structure, treated as a continuous beam, would be sufficient to produce stresses only slightly less than those required to cause failure. In this condition, which might have occurred in a normal flight, the factor of safety would, therefore, be approximately one instead of four. The disaster actually occurred during rudder trials, during which the movements of the elevator were only such as were required to steady the ship. The above-mentioned calculations give a factor of safety of two with the ship turning steadily on an even keel at a speed of 54 knots with the helm hard over, but in actual flight the movements of the ship would not be steady and there would be some additional stresses due to the operation of the elevators. It is, therefore, easy to see that stresses sufficiently high to cause the failure of members weakened by previous straining would be produced in the manœuvre which ended so disastrously.

That the heavy death roll was mainly due to the fire which broke out in the forward portion of the vessel after the parting of the structure was brought out at the Court of Inquiry immediately after the accident, and the Committee accept the findings of the Court that the fire probably originated in a fractured electric lead in proxmity to a similarly fractured petrol pipe. They also emphasise the necessity for keeping petrol pipes and electric leads as far apart as possible in future designs, which is a precaution that may well be taken to increase the safety under normal conditions as well as in the event of an accident.

The Committee also call attention in their conclusions to the need for developing more exact methods of calculation for determining the scantlings of the structural members of airships, and we note that the formation of a panel of the Aeronautical Research Committee to consider this matter has recently been approved by the Air Ministry. There is certainly room for work in this connection, although we feel confident that existing knowledge is sufficient to prevent the recurrence of a failure similar to that of R.38. The failure, we think, was due to the fact that war requirements for the vessel imposed upon the designers a practically impossible task. Past experience has shown, however, that real progress often results from attempting to achieve the impossible, and if this should prove to be the case in the present instance the lives lost in R.38 will not have been entirely wasted.

THE EARLY DAYS OF ELECTRICAL ENGINEERING.

ALTHOUGH this country does not hold the first position either in the extent of the manufacture, or use, of electrical apparatus, the industry is very largely of British origin and its foundations were to a very considerable extent laid here, as is sufficiently indicated by the mere mention of the names Faraday, Hopkinson and Kelvin. That some other countries have moved ahead in the extent of their application of electricity may partly be explained by the fact of our earlier general industrial development, so that electricity in some of its applications had with us to compete with and make a case against established methods which represented large capital expenditure. A further and more important cause of our relative backward position lies, however, in the effect of repressive legislation.

Very much has been said and written at one time and another on the effect of the Electric Lighting Act of 1882, and we do not wish to enter into the question in any detail now, but a remark made by Dr. Ferranti at the Commemoration Meeting of the Institution of Electrical Engineers last week points the moral of the effect of that Act, and the point of view for which it stood, in a very effective way. Speaking of the London Electric Supply Corporation and the early days at Deptford, Dr. Ferranti stated that the intention was to supply the whole of London north of the Thames, an area we take it something like that covered by the Gas Light and Coke Company. Our legislators, certainly in all good faith, decided that this would be bad for the country and as a consequence inaugurated a policy which has led to the present confusion. Had the London Electric Supply Corporation been allowed to proceed with the scheme which was in Dr. Ferranti's mind the task which the Electricity Commissioners are now facing in London would have been of a very different order. Indeed, had electrical enterprise been allowed as free a hand as gas enterprise it is probable there would have been no problem to face.

Although the Deptford station was not allowed to become the starting point of an electric supply system covering the whole of London, it none the less in virtue of the work which was done by Ferranti and his associates, has become the starting point of all high-tension electric distribution throughout the world. The general outlines of the history of Deptford are well known and we need not deal with it in any detail here, but in view of the developments of which Deptford was the origin the occasion of the Commemoration Meeting of the Institution of Electrical Engineers cannot be allowed to pass without a tribute to the extraordinary prescience of Mr. Ferranti and his colleagues in not only deciding on this high-pressure scheme, but in carrying it out against the advice and opinion of practically the whole of the remainder of the electrical world. As Mr. Partridge pointed out in his admirable contribution to the meeting of the 23rd ult., the Deptford scheme introduced the working of transformers in parallel, high-tension concentric cable, paper insulated cable, extra high-pressure generation and distribution, and the oil switch. These are now fundamentals of modern electricity supply.

We do not desire to devote undue attention to Deptford in a brief review of the early days of electrical engineering, but special interest was given to this phase of early days by the personal recollections of Dr. Ferranti and Mr. Partridge. Something of the same sort may, however, be said of the beginning of heavy direct current electrical engineering and the development of the incandescent lamp, and the reminiscences of Colonel Crompton, Mr. Swinburne, Mr. Bernard Drake, Mr. Wordingham, Mr. Patchell, Mr. J. H. Holmes and others were of very considerable interest and value. As he was one of the direct current protagonists in the fight between alternating-current and direct-current, Colonel Crompton's name, in particular, must be an honoured one in the development of heavy electrical engineering. Colonel Crompton did not say so in his interesting and racy contribution to the series of reminiscences, but we believe his works at Chelmsford were the largest electrical manufacturing establishment in the world at the time electrical enterprise in this country received its legislative blight.

Although we have earlier said that we do not wish to enter into the effects of the Electric Lighting Act of 1882 in any detail in this article, yet in explanation of the effect of this Act it may be pointed out that the direct result of the twenty-one years' purchase clause was that capital naturally refused to support electrical enterprise so that private promotion practically ceased. This, however, was not the only result. If municipal enterprise had immediately taken up the work it is quite possible that such a business as that built up by Colonel Crompton might still have received a fair measure of support. The electrical supply business was in those days, however, still a somewhat speculative and experimental one, and it has never been the duty of municipal corporations to indulge in speculative and experimental enterprises. Their position is somewhat analogous to that of trustees and is so interpreted by Government officials. The result was that electrical engineering in this country came almost to a standstill and waited until developments abroad had turned the experimental into the everyday. When that stage was reached it became proper that municipalities should spend money on electrical schemes, but since the modern experience was mostly foreign a considerable part of the plant was bought abroad. This idea that a municipality must not spend its money on experiments is quite sound, but given certain legislation its effect is disastrous. It is quite in recent years that a turbine order for a 3,000 kw. set for a municipality was placed abroad, because the English company which otherwise would have obtained the order could not show a running set of their make larger than 2,500 kw. The proposed 3,000 kw. set was "experimental."

One of the details which must have impressed most of those who listened to the reminiscences of last week was the insistence by so many speakers on the handicaps against which they had to work in having no text books or any source to which they could turn to learn the fundamentals of design. Such things were, of course, not in existence, and matters in this respect were probably not made any better by the fact that most of the pioneer practical work was done by men without any training even in electrical science as it then existed. Colonel Crompton was a mechanical engineer, and the story of his attempts in conjunction with his assistant, Gisbert Kapp, who was also trained as a mechanical engineer, to obtain designing formulæ were amusing and interesting. They were told by the telegraph man and William Preece that all sources of electrical energy, batteries or dynamos, must have considerable internal resistance as a

kick-off from which the electromotive force could make a start to press forward through the external resistance.

Colonel Crompton was connected with practical electrical engineering as early as 1878 when he installed a Gramme dynamo and Serrin arc lamps to enable the pipe moulding pits at the Stanton Ironworks to be run through the night. He commenced manufacturing in the following year, building a machine designed by Emil Burgin and also manufacturing arc lamps. Colonel Crompton was early in touch with Joseph Swan and the incandescent lamp and the burning of the Ring Theatre in Vienna due to an escape of gas gave him an opportunity of carrying out work on a fairly large scale. He spent from 1884 to 1887 in Vienna establishing a central station and attempted to apply the experience gained to work in this country. The 1882 Act blocked the way, but he was able to make a start in 1888 at Kensington Court. This was a direct-current system, and the early days of the direct versus alternating current controversy largely centered round this installation and the Deptford system. Little or nothing is heard of this controversy in connection with ordinary supply work nowadays, but Professor Kapp stated that it was not yet dead. In saying this he was probably referring to the railway electrification question.

We cannot trace the whole of the interesting memories which were revived at the meeting of last week, but before leaving the electric lighting side of early progress we should make some mention of the pioneer installation which was put down by the Telegraph Construction and Maintenance Company at Paddington Railway Station. This installation owed its existence to the fact that Sir Daniel Gooch was chairman of both the Telegraph Construction Company and the Great Western Railway. The plant was described in some detail by Mr. A. H. Walton and was also referred to by Mr. Frank Bailey. It consisted of Gordon dynamos of 400 kw. each driven by vertical engines built by Messrs Rennie. The system fed 4,115 incandescent lamps and 100 arc lamps. There was considerable trouble with the machines and when first installed the generators were found to take more power to drive them with the main switch open than when on load, owing to the inductive effect in the machine. The installation was made a success however, and was taken over by the railway company after twelve months' working.

We cannot leave the heavy side of electrical engineering without referring to the remarkable contributions to modern developments which have been made by Sir Charles Parsons. It is, of course, mainly on his work in connection with the steam end of generating sets that Sir Charles's fame is established, but that in its earlier developments that work had to be accompanied by parallel work on the electrical end is illustrated by Sir Charles's own remark last week that the electric generator of his first turbo-set presented as much difficulty as the turbine itself. This first machine which ran at 18,000 r.p.m. followed work on a rotary engine which Sir Charles designed in 1877 when it was an apprentice with Armstrong, Mitchell and Company at Elswick. Some forty of these engines were built, and it was not until 1884 that his revolutionary work on the turbine was commenced. The first turbo set worked satisfactorily from the start and was used regularly for some years. It was followed by many similar machines which were chiefly used for ship lighting, and gradually the size increased up to the large machines of to-day. The work of Sir Charles Parsons takes second place to no other work in the story of the development of British electrical engineering from its small beginning up to its present position.

Other branches of electrical engineering, for which we do not possess a general term in English, but which at the time with which we are now chiefly concerned were confined to telegraphy and telephony, were dealt with by several speakers including Mr. Campbell Swinton, Mr. Sydney Evershed, Mr. Kingsbury and Sir William Noble. The beginnng of these branches of work are laid somewhat farther back than those of heavy electrical engineering and the pioneers have in general passed away. The memories which were revived last week concerned themselves largely with the taking over of the telegraphy by the State and the commercial introduction of the telephone. A piece of early information of great interest and historic importance was, however, contributed by Mr. Campbell Swinton. Hughes the inventor of the microphone died in 1900, and his widow who died recently bequeathed a number of his note books to the British Museum. Mr. Swinton had been asked to examine these, and had found that during the years 1879–80 Hughes made numerous and successful experiments on the transmission of signals across space by means of what he called the extra current—from a small spark coil. He used a Bell telephone as a receiver with a battery connected in a separate receiving circuit which sometimes included a microphone. The microphone apparently acted as a coherer, and it was at times replaced by a thermo-couple which seems to have played the part of a rectifier.

This was long before the Lodge and Marconi experiments and eight or nine years before Hertz's memorable discovery. Hughes was convinced that the effects he obtained were not due to ordinary electro-magnetic induction and seems to have thought they were to be explained by conduction through the air. From entries in his note books it is clear that Hughes did not consider he received proper appreciation or encouragement from members of the Royal Society in connection with these experiments and he apparently abandoned them entirely. Mr. Campbell Swinton suggests that had they been pursued they might have accelerated the advent of practical wireless telegraphy by some sixteen years. We have already pointed out that the early developments of electrical engineering on the heavy side were all carried out by men without electrical or scientific training. The same thing held in telegraphy and telephony, and Mr. Campbell Swinton pointed out that Hughes was a professor of music, Edison was a railway newsboy, while Bell was a teacher of the deaf and dumb, and Hunning who invented the carbon granule telephone transmitter was a clergyman. Mr. Swinton told an amusing story of Bell to the effect that his friends told him he could not be an electrician otherwise he would have known beforehand that his telephone could not work.

LIGNITIC COALS.

THIS country with its great preponderance of bituminous coals has scarcely needed to pay much attention to the utilisation of its comparatively small deposits of lignite. In many parts of the world, however, deposits of lignite and brown coals are on a very large scale and situated in areas where bituminous coals can only be procured at the expense of costly transport. It is evident that there will be a limit beyond which the cost of transport may make bituminous coal so expensive that lignitic coals of lower thermal value may equal it economically or even surpass it. This is the case in North America, and in Australia. In the former, lignites and brown coals occur in Texas, the Dakotas, Montana, Wyoming, and in Canada, in Saskatchewan and Alberta. The transport of bituminous coals to many of these districts is a costly matter. In Australia the large lignite deposits of Victoria have an advantage in areas such as Melbourne, over the higher grade coals of New South Wales.

The utilisation of these fuels has not advanced either in the United States or in the Empire nearly so far as it has on the Continent of Europe, where, for instance, before the war Germany had an output of about 87,000,000 tons of lignite per annum, and Austria about 27,500,000 tons, while other deposits were successfully worked in Hungary and Italy. It was due to German enterprise also that an attempt was made to utilise the lignite deposits of this country before the war. The process which appears to have been most successful involves drying and subsequent briquetting. In the United States subsequent to the St. Louis Exposition of 1904 a good deal of investigation work was carried out with such fuels. The most promising method of utilisation then appeared to be gasification in producers*, but more recent developments resulting from work over here suggest that lignites of at least some classes can with suitable arrangements be burnt direct under boilers. The great trouble with lignites and brown coals is that they contain a large amount of water. They are not suitable for transport, and when dried turn often to powder. The attempts to use them direct under boilers have usually failed owing to the high water content, the evaporation of which causes such a reduction of the furnace temperature as to render the fuel of low value.

Lignites occupy a place intermediate between peat and bituminous coals. At one end of the scale peat contains 90 per cent. moisture. Dr. W. A. Bone, in a lecture on "Lignites and Brown Coals," delivered on Friday last before the Royal Society of Arts, placed next five classes of brown coals and lignites, with bituminous coals such as Barnsley at the other end of the scale with 2·5 per cent. moisture. Beyond these, again, were the anthracitic coals. The five intermediate classes were:—Brown coals, of which the Italian Val D'Arno, and the Australian Morwell coals were typical, containing from 40 per cent. to 50 per cent. moisture. Brown lignite such as that of Saskatchewan came next with 30 per cent. to 40 per cent. moisture. Black lignite followed with 20 per cent. moisture. This is exemplified by the Malayan coal. The next class, of which the Nigerian coal was an example, could be classed as sub-bituminous, and contained about 10 per cent. moisture. The ash of these coals varied, but the chemical analysis showed a steady increase in the order given for the lignites and brown coals, ranging through 60 per cent. to 75 per cent. carbon, and a decrease in oxygen from 32·35 per cent. to 16·6 per cent., as the moisture decreased. The volatiles are high and range for these coals from 57·8 per cent. to 45 per cent. in the same order.

In the course of work at the Fuel Laboratories of the Imperial College of Science and Technology, South Kensington, Dr. W. A. Bone has tested a good many lignites, including some of the Morwell brown coal from Victoria. The results of these researches were published last year in the Proceedings of the Royal Society, and the chief interest in Dr. Bone's lecture on Friday last lay in the information he was able to give of the practical sequence which has emerged from this work. Dr. Bone's experiments went to show that if the Morwell coal was subjected to a moderate temperature something in the way of a chemical condensation took place. The coal parted with its moisture, and a large quantity of gas, over 88 per cent. of which was CO_2, was given off, while the residual coal was improved from a fuel point of view. The temperature of treatment was below 400 deg. C., a point too low for any of the valuable hydrocarbons to be driven off. The result of this elimination of the moisture and carbon dioxide was to improve the carbon content and calorific value weight for weight, and the residual coal has apparently proved capable of utilisation under boilers.

Some time ago (ENGINEERING, vol. cix, page 287) we gave some account of the large Morwell deposits, and of the manner in which it was proposed to utilise them for the production of electricity supply in bulk for Melbourne. The deposits are worked in open cuts, and machinery is being introduced which will reduce the cost of mining to a very small figure. Dr. Bone stated he had authority for saying the cost to-day was 2*s.* 11*d.* per ton. In the estimates for the scheme it was put at 2*s.* 9*d.* Delivered at Melbourne this fuel would cost about 7*s.* 6*d.* per ton, compared with New South Wales coal at 20*s.* The Morwell scheme does not contemplate the transport of the bulk of the coal to Melbourne, however, but provides for the production of electricity near the mining area, and Dr. Bone's work has, we understand, contributed materially to this, in that it has shown that Morwell coal can be utilised direct with good results. In another column in this issue we illustrate the apparatus devised as a result of Dr. Bone's investigations, the object of which is to heat the coal to a temperature below 400 deg. C. so as to drive off the moisture and CO_2 before putting it on the grate. The preliminary results given by Dr. Bone are promising. In one trial for instance the combustion of the Morwell coal was only 34·9 lb. per hour per square foot of grate, the water evaporated 6,550 lb., and the

* See ENGINEERING, vol. xc, page 898.

furnace temperature about 1,702 deg. F. With the apparatus described elsewhere applied, the combustion could be pushed to 94 lb. per square foot per hour, the water evaporated rose to 20,200 lb., and the furnace temperature was maintained at 2,100 deg. F. The maximum evaporation worked out at 8·7 lb. of water per square foot of heating surface. The waste gas temperature was only slightly higher in the latter case than in the former. It must be mentioned that these figures are only preliminary results as much more complete trials are now in progress. They show, however, a good deal of promise, and when the extent of these deposits is realised it will be understood how important it is to make practicable the use of this low-grade fuel. The area under which this coal has been proved is 50 miles long, and within 1,000 ft. of the surface there are estimated to be 31,144 million tons of coal. No less than seven beds have been proved within this 1,000 ft., and these aggregate over 780 ft. in thickness. The thicknesses are in round figures, 29 ft., 26 ft., 23 ft., 228 ft., 266 ft., 166 ft., and 44 ft. These figures are certainly sufficiently attractive to warrant the endeavour now being made by the Victorian Government to put this fuel to practical use.

THE BRITISH INDUSTRIES FAIR IN LONDON.

THE London Section of the British Industries Fair, which opened simultaneously with that at Birmingham, dealt with elsewhere in this issue, is being held at the White City, Shepherd's Bush, and includes a very extensive collection of goods such as chemicals, soaps, furniture, brushes, cutlery, plate, jewellery, leather and fancy goods, stationery, &c. The exhibits of technical interest, however, are by no means numerous and are confined to one section in which china, earthenware, cut glass and similar articles are also included. Perhaps the most striking exhibit in this section is a collection of kinematograph projectors, cameras, printing apparatus, lamps, and accessories of all kinds made by various firms and collectively exhibited by the Incorporated Association of Kinematograph Manufacturers, Limited. Scientific and technical glassware is shown by John Moncrieff, Limited, of Perth, Scotland, and by Wood Brothers Glass Company, Limited, Barnsley, while lenses and prisms, mainly for ophthalmic work, but also for general technical applications, are exhibited by the United Kingdom Optical Company, Limited, Mill Hill, N.W. 7.

The exhibit of Messrs. Adam Hilger, Limited, Camden-road, N.W. 1, includes a selection of their well-known optical instruments, but the most important item from a technical point of view is the apparatus for annealing glassware; this, however, we hope to deal with on a future occasion. Mention should also be made of a simple set of apparatus for testing metal surfaces, such as slip gauges, by interference, in which the necessary monochromatic light is obtained from daylight by using a coloured glass screen. The apparatus can be used for measuring the irregularities of so-called plane surfaces as well as for measuring small differences in length and thickness to within about $\frac{1}{140000}$ in.

A new line of drawing instruments, constructed mainly of stainless steel, is shown by Messrs. Norton and Gregory, Limited, Castle-lane, S.W. 1. The steel used in these instruments is specially hardened and tempered so that they require less setting than similar instruments of ordinary steel, and the stainless steel has the obvious advantages that it is unaffected by the acids used in coloured inks and will not rust in damp climates. Cheaper instruments for students' use are also shown. A fine collection of X-ray and electro-medical apparatus is exhibited by X-rays, Limited, Torrington-place, W.C. 1, including a cabinet set containing a transformer, Coolidge tube and fluorescent screen for the examination of materials and manufactured parts. The screen measures 12 in. by 9 in. and the penetrative power of the apparatus is such that steel parts up to about ¼ in. thick, and wooden objects up to 3 in. or 4 in. thick, can be examined.

Messrs. Short and Mason, Limited, of Walthamstow, E. 17, show a variety of aneroid barometers for meteorological, surveying and mining work, as well as mercury thermometers, anemometers, recording rain gauges and other meteorological instruments. We also noticed at their stand a gas-leak indicator operating on the diffusion principle. This instrument contains a metal cylinder, one end of which is closed by an elastic diaphragm and the other by a porous tile. When brought into an atmosphere charged with gas, the effect of diffusion through the porous tile is to increase or decrease the pressure in the cylinder and thus deflect the diaphragm, the movement of which is indicated by an index hand and dial. The instrument can be used for locating leaks in underground gas mains. Silica globes and shades for gas and electric light fittings are shown by the Thermal Syndicate, Limited, 28, Victoria-street, S.W. 1, and laboratory apparatus, including autoclaves with a new and improved form of lid, is displayed at the stand of Messrs. Brown and Son, Wedmore-street, N. 10. Chemical and other balances are exhibited by Messrs. W. A. Webb, Limited, Skinner-street, E.C. 1, and by Messrs. L. Oertling, Limited, Turnmill-street, E.C. 1. The latter firm also show an automatic coin-weighing machine for use in mints and banks. The exhibition will remain open until the 10th inst. but admission is confined to trade buyers, who can obtain invitation tickets from the Department of Overseas Trade, 35, Old Queen-street, Westminster, S.W. 1.

NOTES.

METALLURGY IN RELATION TO MECHANICAL ENGINEERS.

SIR HENRY FOWLER had little difficulty in the task he set himself, on Monday last, when he delivered the Annual Graduates' Lecture at the Institution of Mechanical Engineers, in proving the need on the part of mechanical engineers of some knowledge of metallurgy. He did not attempt to discuss the subject from the metallurgist's point of view, or of that of the metallurgical chemist, but from the point of view of an engineer, who realised what metallurgy had done for, and how necessary it was to, the profession. Engineers were indebted to the physicist for heat treatment, and to the chemist for exact proportioning of alloys, &c. There had been no important discovery in metallurgy which had not had an immediate effect on mechanical engineering. Sir Henry called to mind the historic early discussions before the Institution of Mechanical Engineers, and proceeded to give a number of examples in which metallurgical knowledge had enabled small changes of treatment or in analysis to be made, with beneficial results as regards brittleness or bad machining qualities, &c. Sir Henry's examples ranged over steel, brasses, aluminium, &c., and were well selected for the purpose in view, namely of interesting the younger members of the profession in a subject which some are rather inclined to think too academic for the practical engineer. Sir Henry was able to show that an appreciation of the work of the metallurgist was as necessary to-day to the mechanical engineer as was a knowledge of mathematics, and cited the motor car and aeroplane as two products of mechanical engineering which it would have been impossible to bring to their present state of development but for the assistance given by metallurgical knowledge and research.

TRAILING CABLES FOR ELECTRIC MINING MACHINERY.

Few pieces of apparatus meet harder conditions of service than the flexible trailing cables which are used to connect up electric coal cutters and other machines in mines, and that the importance of the question of the best form of such cable has been impressing itself upon the public notice in the United States is illustrated by the fact that a conference devoted to the subject was held at the Pittsburg Experimental Station of the Bureau of Mines on January 10 last. The conference was attended by manufacturers, operators and officials of the Bureau of Mines. In American practice the smaller sized cables are made with 49 wires and the larger with 133, and apparently the cable makers were of opinion that there is a tendency to use too small a sectional area for the current to be carried. Increase in cable sizes was opposed, however, by operators owing to the difficulty of handling and reeling cables of large area. It was suggested that the smaller cables could be protected by the insistence of a requirement that the circuit voltage should not be allowed to fall below a predetermined value. Cable makers also argued that a better grade of insulation was required for mine service than was specified in the code requirements. They were working on the subject, and would probably be willing to co-operate in the establishment of standards. Conductors "having a rubber outer covering similar to that used on automobile tyres" had been tested out by the Jeffrey Company and were strongly recommended to the conference. This is evidently the excellent type of protection known as "cab-tyre sheathing" in this country, and the proceedings of the conference would suggest that it is not generally familiar in the States. We suggest it is likely to assist in meeting some of the difficulties which are evidently being experienced. A further point dealt with was the protection of the terminal ends of trailing cables. The Bureau of Mines at present requires satisfactorily insulated handles or other means of connecting cables to the source of power without danger to the person making the connection, and it was suggested that for use in fiery mines some arrangement incorporating an interlocking switch should be employed. No suitable switches are at present on the market, but operators are prepared to use them if they become available and the State Mines Department would probably make them compulsory.

THE IDEAL HOME EXHIBITION AT OLYMPIA.

The Ideal Home Exhibition organised by the *Daily Mail* was opened on Wednesday afternoon by Her Royal Highness Princess Alice, Countess of Athlone. It will remain open until the 25th inst. The exhibition this year does not show so much in the way of new methods of building as formerly, and the treatment of interiors forms its chief feature. Examples of well-known concrete block systems are to be found, and the building exhibits include one by Messrs. Concrete Dwellings (Parent Company), Limited, of 1, Carteret-street, Westminster. This firm shows a travelling mould for making monolithic concrete walls, the model now exhibited forming continuous hollow walls *in situ*. The majority of the exhibits concerned with house interiors are extremely attractive, but are naturally somewhat outside our sphere. Sanitary ware of the bath room class is well represented and well displayed. Various lighting systems for small houses are to be found, including many of the well-known petrol-air gas and acetylene plants. Small electric plant is also prominent, including all classes of non-automatic, semi-automatic and full automatic systems. Among these exhibits may be mentioned those shown by Messrs. Rashleigh, Phipps and Co., Limited, 147, Oxford-street, W.1; Messrs. Mann, Egerton and Co., Limited, Ipswich; the Lalley plant of Messrs. Studebaker, Limited, Great Portland-street; the Ballot and Hamworthy sets of Messrs. Hick Diesel Oil Engine, Limited, 70, Queen-street, E.C., and so on. A number of examples of full automatic Lister-Bruston sets are to be seen at the stand of Messrs. R. A. Lister and Co., Limited, Dursley, while the Austin Motor Company, Limited, Northfield, Birmingham, are also showing full automatic plant, including a new 2 kw. "Autoplant" suitable for up to one hundred and twenty 20-watt lamps. This set is coupled direct to a 3·5 b.h.p. Austin motor running on petrol, paraffin or town gas. Air cooling is employed for the dynamo, and everything arranged so that the least possible attention is required. This firm also shows an "Auto-Dynamo" for belt drive with switch gear on the same principle. The Aster Engineering Company (1913), Limited, of Wembley, are showing their small "Aster British Light," which is of extremely compact design. This is of the semi-automatic class. The exhibition includes many examples of water-softening systems, while naturally stoves, ranges, and other heating arrangements, together with a large variety of electrical appliances, are also prominent. The exhibition is well arranged in sections so that in most cases things of one type are grouped within easy distance, rendering comparison easy for those interested.

THE LATE MR. JAMES MARSHALL.

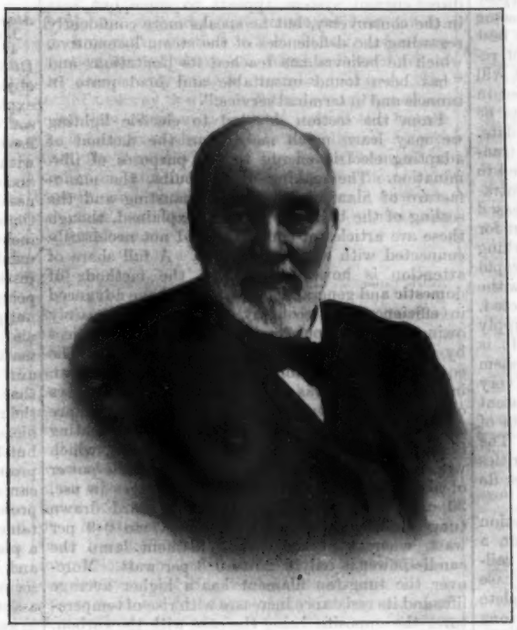
A LINK going back to quite the early days of agricultural engineering has been broken by the death, after a long illness, of Mr. James Marshall, which occurred at his residence, Gainsborough, on Sunday night last. Mr. Marshall was born at Manchester as long ago as 1836, and his connection with Gainsborough goes back to 1848, when his father, the late Mr. William Marshall, purchased an old-established engineering and wheelwright business in the town, and in this business the subject of our memoir obtained his early training. The family originally came from Manchester, where, as already stated, James was born, but they were for some time resident in St. Petersburg, where Mr. William Marshall held an engineering appointment, prior to the purchase of the Gainsborough business.

The beginnings of the Gainsborough factory were on a very small scale, its activity being confined to millwright work in connection with local oil and flour mills, to which was added later the manufacture of threshing machinery and still later that of portable and fixed engines. The business steadily grew, however, and a plot of ground of 1½ acres was purchased, and what was the nucleus of the present works was erected on it in 1855–56. A year after this, in 1857, James, then 21 years of age, was taken into partnership by his father, and the name of the firm was changed to William Marshall and Son. Four years later, in 1861, the late Mr. Henry Dickenson Marshall, a younger brother of James, also joined the firm, and the name was then changed to William Marshall and Sons. In this year Mr. William Marshall died, and the two sons continued the business, which was converted to a joint stock company in 1862, with James and Henry D. Marshall as managing directors.

The history of the Marshall works from that time forward is a story of continued growth and success, and the two brothers built up a business on which it may be said that at one time practically the whole of the fortunes of the town of Gainsborough rested. The long partnership was broken in 1906, when Henry Marshall died at the age of 66, but a younger generation of Marshalls had by that time arisen to assist in carrying on the firm. An obituary notice of Mr. Henry Marshall will be found in our issue of March 16, 1906, page 351, while accounts of the factory appeared in our issues of August 7, 1885, and May 14 and 21, 1920. This latter recent account gives a very full description of the works as they now exist, and may be referred to for details to fill out the brief outline description of the growth of the works which is all that we are able to include in the present article.

The works built in the 1½ acres to which we have referred above formed the beginning of what is now the Britannia Works. That progress was rapid from the first is shown by the fact that by 1870 the area occupied by the factory had increased to 4½ acres, and the number of men employed reached 550. By 1880 the works had expanded to 15½ acres and the employees to 1,310. Ten years later the area occupied was 20 acres and the employees numbered 2,200. In another ten years the figures were 34 acres and 3,000 employees, while in 1910 the area was 39 acres and over 4,000 men were employed. The present area is 45 acres. The whole of the extensions indicated above did not take place at the Britannia Works, as the Trent Works were commenced in 1892 and the Carr House Works in 1911, while the new power-house, which is independent from the works and erected on a convenient site adjoining the River Trent, was begun in 1917. The various shops and works are laid out each for their special type of product, and the range of manufacture now covers steam tractors and traction engines, road rollers, portable and semi-portables, fixed engines of vertical and horizontal types, drop-valve mill engines, oil engines, vertical, locomotive, Lancashire and other types of boilers, threshing machinery, maize shellers, elevators, tea machinery, flax machinery and decorticators for fibres.

In the enterprise and energy which built up this remarkable business, it is impossible and unnecessary to attempt to disentangle the respective parts played by James and Henry Marshall. The work of the brothers was so intimately associated that praise for the remarkable advances made must be shared equally. The firm during its career has turned out some 175,000 engines and boilers, and although these were of many types and classes, and did not lend themselves to the mass production methods of a factory turning out a single article, it is of great interest to note that specialised machinery methods, finished-part stores and other features of modern practice were brought into full use at Gainsborough very many years ago, without any necessity being found for inventing special names for them. The success of the firm did not, however, depend only on good manufacturing methods, but also on a vigorous business policy, and the trade connections they made and retained in the Far East and on the Continent gave them a large market and, incidentally, certainly assisted in establishing the good name of British engineering work abroad.



THE LATE MR. JAMES MARSHALL.

The firm at all times took an interest in the technical education of their men, and in quite early days classes were held in the office buildings, under the Science and Art Department of South Kensington, in machine construction and drawing, mechanics, &c. This work was developed later, and at both the Britannia and Trent works there are now science and art class rooms and laboratories where regular courses of instructions are carried on. The schools are divided into three sections, dealing respectively with engineering, commerce and art, and junior and senior courses are arranged, the former extending over two and the latter over three years. There is a mechanical laboratory at the Trent Works equipped with an 8-h.p. compound steam engine with a boiler of the locomotive type, together with testing machines, various instruments, &c. The engineering courses cover machine drawing, the steam engine, mathematics, physics, &c. The mechanics and physics classes are taken at the Gainsborough Grammar School laboratory. The commercial courses cover English, French, book-keeping, shorthand, &c.

Mr. James Marshall, although he naturally passed an exceedingly busy life superintending the growth of the business we have described, also took an active part in affairs outside the immediate interests of his firm. He became a member of the Institution of Mechanical Engineers in 1871, but did not take any considerable part in their proceedings. He was for very many years a Justice of the Peace and was highly esteemed for the admirable way in which he carried out his magisterial duties. He was also an Alderman of the Lindsey County Council. He was also President of the Gainsborough Dispensary, and was associated with many local institutions and organisations, particularly those of a charitable nature. The Institute and Gymnasium in Church-street, Gainsborough, was also erected and completely fitted up by him as a memorial to his wife.

Throughout his life Mr. Marshall was greatly interested in educational matters, and, as explained above, in connection with his brother, Henry Marshall, established technical classes in his works long before anything of the kind was at all common, especially in the smaller provincial towns. A man of the highest character in every sense of the term, he was universally respected and his loss will be deeply felt, especially by those personal friends who had been associated with him during his long and successful career, and by the large number of those who have in times of stress and trouble benefitted by his keen sympathy and generous aid so freely rendered. He leaves behind him two sons, Mr. Herbert John Marshall and Mr. Hugh Marshall, both of whom have long been associated in the management of the firm.

THE KAYE MOTOR CYCLE OIL CAN.—We have received from Messrs. Joseph Kaye and Sons, Limited, 93, High Holborn, London, W.C. 1, a sample oil can of a specially strong construction for the needs of motor cyclists and others. The cylindrical tin-plate body has a serrated circumferential seam which should withstand very hard usage. The brass spout is screwed into the body in the ordinary way, and terminates in the usual screwed cap with clearing pin.

LITERATURE.

Electricity in the Service of Man: A Popular and Practical Treatise on the Applications of Electricity to Modern Life. By R. MULLINEUX WALMSLEY, D.Sc., F.R.S.E., M.I.E.E. Vol. II. *Technology of Electricity.* Section III. Cassell and Co., Limited. 1921. [Price 15*s.* net.]

THE first volume of this work, giving details of the generation and general handling of electrical power, appeared some time back, and in this volume the author is more particularly concerned with the methods by which electric energy is made to serve industry and the arts. The main subjects discussed are electric traction, electric lighting and plating, and the operations connected with electrothermics, as electric furnaces, electric welding, &c. The work has already extended to more than 2,000 pages, and as the numerous applications of electricity are by no means exhausted, other volumes will doubtless appear. The treatment is conducted therefore on very generous lines, and the amount of detail described is enormous. The repetition of the description of practically identical pieces of mechanism, intended to effect the same purpose is apt to grow wearisome. There may be some difficulty in deciding whether the work were best described as a technical manual or a work of reference for general information. Doubtless it will "contrive a double debt to pay," as suggested in the secondary title, and however the contents be used, they will be found trustworthy and up-to-date.

The first subject dealt with, namely, electric traction, occupies practically half the book, is entitled to the prominence the author gives it. The concentration of population in large cities and the increased traffic involved would be quite impossible, but for the facilities electric traction affords in the working of underground railways and urban surface rapid tramway service. We cannot, of course, follow the author in the wealth of detail that he has collected, and which covers the whole field of the supply of energy to the purposes of locomotion. It is sufficient to say that the overhead trolley system and the underground or conduit system are very fully discussed and illustrated, and not content with these two main systems, details are given of the much less used plan by surface contact. The author spreads his net wide, and the peculiarities of petrol electric vehicles and of automobiles do not escape a thorough examination.

The impression left by the study of this section is that electric traction is now established on a sound and commercial basis. Already steam railways have had to adopt the mechanism in the case of suburban traffic, where it has proved a complete engineering success, and the electrification of long main line railways is a pressing problem of the immediate future. The president of the American Institute of Electrical Engineers has pointed out that the coal consumption in the United States amounts to 150,000,000 tons per annum, and that two-thirds of this amount could be saved, if electrification were universally adopted. Under average conditions, 6 lb. of coal are required per horse-power hour on steam locomotives, whereas in electric traction, the consumption need not exceed 2 lb. per horse-power hour, if the energy were supplied from large central generating stations, account being taken in this estimate of all the losses in generation, in transmission, and in the motors on the trains. The price and the growing scarcity of coal alike demand, that the greatest output from the fuel expended should be obtained, and in the past the degree of efficiency attained from steam power cannot be regarded with any great satisfaction.

Delay in the progress of railway electrification can doubtless be traced to the uncertainty that attaches to the relative advantages of the use of direct and alternating current, and closely connected with this problem, are the merits of the single-phase and three-phase systems. The author's review of these old controversies is informative, and his position is detached and impartial. If he draws no definite conclusion, but is content with a moderate statement of his own convictions, probably the time for decision has not arrived. For short-line railways with rapid service and frequent stops —and in this country experience is practically confined to such examples—the advantage lies on the side of a direct-current system, with its lower cost of working and equipment. On the other hand, for the electrification of long main line railways, some form of alternating current will probably have to be employed, owing to the great advantages it possesses in ease of transformation. The advantages of three-phase and one-phase seem fairly well balanced. Switzerland and the Continent have generally preferred three-phase currents, and three-phase induction motors. These motors are said to have the advantage of light weight per horse-power, but they have the disadvantage of running at nearly the same speed for all loads, putting an undue strain on the generating station at times. Single-phase alternating current motors are larger, heavier, and call for a greater initial outlay than does a direct-current motor of equal horse-power. But in single-phase work, the current can be transmitted at high voltage, and taken up from the trolley wire or third rail, and transformed to the necessary lower pressure for the motor by means of static transformers on the locomotive. Dr. Walmsley intimates that for general purposes, the high voltage direct-current system appears to come out best in the controversy, but he speaks more confidently regarding the deficiencies of the steam locomotive, which he believes has reached its limitations and "has been found unsuitable and inadequate in tunnels and in terminal service."

From the section devoted to electric lighting we may learn much more than the method of adapting electric energy to the purposes of illumination. The making of the bulbs, the manufacture of filament wire, the exhausting and the sealing of the bulb, are all fully explained, though these are articles of commerce and not necessarily connected with electrical science. A full share of attention is however given to the methods of domestic and general lighting, which have advanced in efficiency and economy in late years, mainly owing to the encouragement given to the subject by the Society of Illuminating Engineers. The equality of illumination, especially, has acquired an importance that was disregarded in the early days of electric lighting. Naturally, many lamps are described, but the problem of domestic lighting is apparently solved in the tungsten lamps, which with low voltage can be made to give a candle-power of about 10, and with the higher voltages in use, 30 c.p. The luminous efficiency of hard drawn tungsten wire lamps varies from 0·7 to 0·9 per watt, whereas in the carbon filament lamp the candle-power is only 0·25 to 0·3 per watt. Moreover the tungsten filament has a higher average life, and its resistance increases with rise of temperature, the opposite being the case with the carbon. But the lamp's efficiency may depend much on its fitting, and how these can be best arranged to combine an artistic appearance with efficient illumination are points on which the author can offer much good advice. But we think the author has nothing to say on the use of electric lamps for miners, and, the reduction in the number of instances of nystagmus that has followed its judicious use. It would seem natural as the method of electric wiring in houses is treated rather elaborately, to have entered into the related subjects of house heating, and cookery by electricity, but these topics are left untouched. Similarly meter measurement, a matter of some importance to the householder, does not find a place in this section, but some systems are described in a later chapter on electric measurements in power circuits.

One of the oldest industries that has its origin in electrochemistry is that of electroplating, and perhaps is the one that has varied least from its manner of earliest application, though the related process of electrotyping has been vastly increased. The voltages used being low, and the insulation presenting little difficulty, have contributed to the constancy of practice. The modern art of electroplating largely consists in profiting by the accumulated experience of the past in the choice of the electrolyte to be used in order to secure a coherent and commercially useful deposit. Considering the importance that electrolytic copper has acquired in industry, this subject might have been treated more fully. The production of aluminium by the Hall-Héroult process seems to have escaped attention.

The work of electric furnaces is essentially a modern process, and every month witnesses the introduction of some new method or application. Here the author has a large subject, and seems to be rather cramped for space. It is not very satisfactory to be told that the examples given do not exhaust the applications of electric furnaces in industrial production, and to have presented a bare catalogue of other uses, when this catalogue contains such important processes as the formation of nitrates and nitrides from the atmosphere, the manufacture of carborundum, of graphite, of aluminium, of carbide, "and of other materials which play an important part in modern industrial life." But if certain matters are omitted, or only lightly commented upon, that does not lessen our admiration of the patience and ability that has collected so many facts, digested them with care, presented them attractively and illustrated them judiciously. This encyclopædic work will certainly be found in the libraries of many technical institutions, and will be welcomed by electrical engineers.

Atomic Theories. By F. H. LORING. Illustrated. London: Methuen and Co., Limited. 1921. [Price 12*s.* 6*d.* net.]

DURING the last few years, the atom has been the object of so much study and experiment, that to explain the new facts collected from very varied sources, numerous hypotheses and speculations have had to be advanced. To summarise these within one moderate volume is a difficult task, and one that is perhaps incompatible with completeness and lucidity. The author in his well-intentioned endeavour to cover a large ground, and to include in his review the latest results from experiment and from discussion, has failed to do himself justice. Time is necessary to provide a proper perspective of all the contributing details, and it is not possible to indicate what will prove permanent and valuable among much hastily digested information. The author admits that in pursuit of his aim to bring together those facts and theories, that on account of their novelty have not yet found their place in text books, he has had to include some ideas which have not been thoroughly established, but he defends this course by urging his desire to present as many views as possible, provided these can show some support from experiment, for it is probable that a certain amount of truth is contained in each, though not the whole truth. Such a plan throws the task of selection on the reader, and he needs to be assisted by a logical and consecutive arrangement of all the cogent facts. This assistance, we submit, might have been rendered in ampler measure.

It is necessary to assume some acquaintance with the progress of physical science in the last twenty years, since Sir J. J. Thomson demonstrated the divisibility of the atom and succeeded, in co-operation with other physicists in raising the electronic theory of matter to the scientifically sound position it holds. The author is quite justified in omitting all reference to experimental proofs; making sufficient mention of the accepted facts and the evidence on which they rest, but the order followed in the account of modern work seems strange, though necessarily the pursuit of several lines of investigation, simultaneously, by many workers, confuses some of the issues. The intention appears to have been to emphasize the mechanism of the atom rather than the behaviour of the electron. Such intention might explain the early mention of the isotopes of lead and the work of Dr. Aston, who has succeeded so brilliantly in eliminating uncertainties arising from complex radiation, and in demonstrating that the important property of an element is the atomic number or the positive charge on the nucleus of the atom which alone determines the chemical properties of the element. The evidence produced hitherto has been drawn mainly from physical research, and the attitude of chemists towards the conclusion is not very clearly pronounced. The author's review of Dr. Aston's work is slight and disappointing, inasmuch as he does not indicate its far-reaching nature in disturbing conventional ideas regarding the elements chemically considered.

To Mosley's work, earlier in time, is an easy step, and is accorded a more generous treatment, and the change of frequencies by definite steps in passing from element to element is well illustrated. But though the author views with favour the hypothesis that the atoms of the elements are built up of hydrogen nuclei and electrons, he makes no use of Mosley's work, though it supplies very material evidence, that the elements are built up in some such manner. The description of the work of Sir W. H. and Professor W. L. Bragg on crystal analysis follows the usual lines, and though quite adequate for those familiar with the method, would have been easier to follow if more details were given. The curious fact that analysis of crystals of KCl has failed to exhibit any structure corresponding to the KCl molecule is not specifically mentioned. It might be inferred from a diagram, if it is appreciated that each potassium atom is symmetrically situated with regard to six chlorine atoms. If the potassium and chlorine atoms are bound in pairs by a valency bond, this structure is difficult to understand and some further explanation might have been vouchsafed.

The experiments of Professor Sir E. Rutherford, detailed in the Bakerian lecture of 1920, demonstrating the disintegration of nitrogen atoms by collision with an α particle are well and appreciatively described. It is difficult to explain why such a momentous achievement as the breaking up of the nitrogen atom has failed to attract a greater degree of public enthusiasm. Possibly its importance is not understood, and in that case the author's popular description is the more welcome. The evidence excludes the possibility that the particles detected by their scintillations on a zinc sulphide screen result from any hydrogen contamination, for the H atoms of nitrogen have a much greater range than the H atoms from hydrogen. Moreover, later and improved methods of conducting the experiment have shown that long-range particles can be similarly liberated from such elements as boron, fluorine, sodium, aluminium, &c., the range from the last-mentioned metal being as great as 80 cm. The experimental evidence of the nature of the particles emitted from these metals is not so certain as in the case of nitrogen, but there is great probability that the particles are really H atoms, liberated at different speeds from the elements. This view is the more probable, as carbon, sulphur, oxygen and chlorine among others fail to give any trace of the discharged particles, and generally, no effect is observable if the atomic mass of the element is given by $4n$ where n is an integer, but the effect is marked, when the mass is expressed by $4n + 2$ or $4n + 3$. Sir E. Rutherford remarks that such a result was to be anticipated, if atoms of the $4n$ type are built up of stable helium nuclei, and those of the $4n + a$ type of helium and hydrogen nuclei.

To the work of Bohr and the development of his hypotheses by Sommerfeld, Langmuir and others, the author renders a similar service to that paid to Rutherford and his colleagues. Bohr, availing himself of Planck's theory of radiant energy exchanges or emissions, and assuming that the electrons are in rapid revolution in circular orbits round the positive nucleus of the atom, evolved a theory which always had much to recommend it, and by progressive development at the hands of various physicists, has been adapted to meet fresh experimental facts as they have arisen. Confining attention to hydrogen, one of the features of this hypothesis, is that the monochromatic radiations are supposed to occur, when an electron makes an excursion from an outer orbit to an adjacent inner one. It is claimed that this theory in its original form, explained, or interpreted, the Balmer formula for the position of the observed lines of hydrogen, supplied an evaluation of the Rydberg constant, and offered a solution for some other observed phenomena. Professor Sommerfeld has improved on the original hypothesis by substituting elliptical for circular orbits, and making the mass of the rotating electrons to vary during its orbital motion. As the number of facts to be explained increases, the mechanism of the atom does not grow simpler, and the introduction of the Langmuir theory further complicates the conception. A study of the diagram of the suggested working models of the oxygen and nitrogen atoms shows how the original conception has grown. These models are founded on the experiments and deductions of Rutherford and Langmuir, and the author endeavours to show, not as we think very successfully, that there is substantial agreement between the views of the two physicists. He himself, however, gives the caution: "It should be realised that certain fundamental facts are in the process of co-ordination, and just what the final adjustments will be, to make the mechanism a complete working model, cannot be foretold with certainty. This remark applies generally to the atomic theories recorded and discussed throughout these pages."

This remark might suggest that the appearance of such a book is premature, but it is justified by the fact that it is instructive to see the process by which knowledge is acquired, and to follow the tortuous route to the goal. The attempts to co-ordinate the new discoveries and conclusions are specially welcome. They are suggestive and fruitful, and it is not their least value that they demonstrate the irreconcilable. Experimental research in the atomic theory has led to new views of valency, suggested fresh sources of heat for the sun, brought magnetism within the range of atomic phenomena and above all, furnished proof where previously only vague surmise existed. The author's survey is wide, embracing many questions. In his last chapter, doing this journal the honour of quoting from the report in its columns, he presents the recent views of Sir J. J. Thomson on Radiation, and here as elsewhere, he shows that experimental physics has embarked on a new life, and that new weapons are successfully attacking old problems.

See-und Seehafenbau. By H. PROETEL. Berlin: Julius Springer. [Price 40 marks, bound.]

A GOOD many of the "new" books which now reach us from Austria and Germany had practically been completed before the outbreak of the war, and one rather wonders that the publishers should now risk publication. Information, which was accessible to competent men among the Allies even during the war and which certainly has become so within the last two years, apparently still remains beyond the reach of Continental writers. This should be borne in mind when criticising new Continental publications, but it does not much affect Baurat Proetel's volume on "Maritime Construction and Sea Ports." Apart from the field of signalling there have been few innovations in maritime matters and sea-port construction, and Mr. Proetel's strong point lies, in any case, in the first three of his six chapters which deal with the sea, winds, waves, tides and currents, and with coasts and estuaries and their protection. There we get some valuable information on problems which concern the authorities and the local harbour engineer rather than the large contractor.

When we come to the fourth chapter, navigation at sea, we are less satisfied. The pages of historical notes and nautical principles might well have been omitted; that would have saved a dozen pages, which after all is something in a volume of 220 pages, and a little more might then have been said on modes of signalling, buoys, lighthouses and lightships. We do not dwell upon the fact that no references are made to submarine, radiotelegraphic and other methods of signalling, developed during the war, though the separate German solutions of these problems, which the Allied scientists attacked more in co-operation, would have been of interest. But the information given is too general, and the same remark applies also to the next chapter, that on sea ports, and particularly to the last chapter, that on sea canals. In fact, the 10 pages on the latter would hardly be missed if cut out. We should be less critical if there were more references to works consulted. Most of these are tabulated in two pages at the end of the volume, and in the case of books the date of publication is frequently omitted. The treatment of the subjects generally, however, is appropriate throughout, the language lucid, and the book, with its 292 illustrations, certainly gives as much as can reasonably be expected from a volume of its compass. The good paper and type deserve mention.

BOOKS RECEIVED.

The Albert Owners' Handbook and Catalogue of Spare Parts. London: The Service Motor Company, Limited. [Price 5s.]

Is Trade Unionism Sound? A Suggestion for Outflanking the Power of Capital. By J. H. BUNTING. London: Benn Brothers, Limited. [Price 2s. 6d. net.]

Garcke and Fells: Factory Accounts in Principle and Practice. A Handbook for Accountants and Manufacturers. With foreword by J. M. FELLS, C.B.E. Seventh edition, revised and brought up to date. London: Crosby Lockwood and Son. [Price 15s. net.]

Anales de la Secretaría de Comunicaciones y Obras Publicas. Third Series, Vol. III, 1921. Mexico: Departamento Universitario y de Bellas Artes.

Boletín de la Secretaría de Comunicaciones y Obras Publicas, September, 1921. Mexico: Departamento Universitario y de Bellas Artes.

Informes de las Dependencias de la Secretaría de Comunicaciones y Obras Publicas del 11 de Abril al 31 de Mayo, 1920. Mexico: Departamento Universitario y de Bellas Artes.

A List of English Clubs in all parts of the World, 1922. By E. C. AUSTIN-LEIGH, M.A. London: Spottiswood, Ballantyne and Co., Limited. [Price 7s. 6d. net.]

Report of the Inter-Departmental Committee appointed to Consider the Methods of Dealing with Inventions made by Workers Aided or Maintained from Public Funds. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 6d. net, post free 7d.]

Los Alogamientos Militares en la Republica. Mexico: Departamento Universitario y de Bellas Artes.

The Oil Encyclopedia. By MARCEL MITZAKIS. London: Chapman and Hall, Limited. [Price 21s. net.]

United States Bureau of Foreign and Domestic Commerce. Statistical Abstract of the United States, 1920. Washington: Government Printing Office. [Price 50 cents.]

United States Bureau of Labour Statistics. Bulletin No. 281. *Proceedings of the Seventh Annual Meeting of the International Association of Industrial Accident Boards and Commissions, San Francisco, California. September 20 to 24,* 1920. Washington: Government Printing Office.

Lockwood's Builders, Architects, Contractors and Engineers' Price Book, 1922. Edited by J. P. ALLEN. London: Crosby Lockwood and Son. [Price 7s. 6d. net.]

Questions and Answers Relating to Diesel and Semi-Diesel and Other Internal-Combustion Engines. Air Compressors, &c. By JOHN LAMB, M.Inst.Mar.E. London: Charles Griffin and Co., Limited. [Price 5s. net.]

AUSTRALIA'S SHARE IN THE WAR.—The first volume of the "History of the War," so far as Australia's share in it is concerned, has been published by Angus and Robertson, Sydney, by arrangement with the Federal Government. It has been written by Mr. C. E. W. Bean, Official War Correspondent to the Australian Imperial Force, and deals with the period from the outbreak of war to the first phase of the Gallipoli campaign. The whole history will be completed in 12 volumes, 6 of which will be written by Mr. Bean, and the remainder by other well-qualified writers who were connected with the A.I.F.

EXAMINATIONS FOR MINE MANAGERS AND SURVEYORS.—An examination for first and second class certificates of competency as manager and under-manager of mines will be held on May 24 and 25, at Edinburgh, Newcastle-upon-Tyne, Sheffield, Wigan, Cardiff and Birmingham. The written part of an examination for certificates of qualification as surveyor of mines will be held at the same places on May 25. Candidates must, on or before April 2 send their names, stating also the district in which they are employed, to the Secretary at the Mines Department, 46, Victoria-street, London, S.W. 1, from whom all particulars can be obtained.

CIVIL AVIATION ADVISORY BOARD.—The Air Ministry announces: The Civil Aviation Advisory Board, the creation of which was announced by the Under-Secretary of State for Air at the recent Air Conference, has now been set up with the following terms of reference: "To advise generally on the development of civil aviation and to report upon any specific point which may, from time to time, be referred to the Board by the Secretary of State for Air." The constitution of the Board is as follows: The Under-Secretary of State for Air (the Right Hon. Lord Gorell), chairman; the Controller-General of Civil Aviation, Air Ministry (Major-General Sir Frederick H. Sykes); the Director-General of Supply and Research, Air Ministry (Air Vice-Marshal Sir W. G. H. Salmond). Representatives of: General Post Office (Brigadier-General F. H. Williamson); Air League of the British Empire (Major-General Sir W. Sefton Brancker); Association of British Chambers of Commerce (Mr. Edward Manville, M.P.); Federation of British Industries (Mr. H. James Yates); Lloyd's (Lieutenant-Colonel Sir Frederick Hall, M.P.); Royal Aero Club (Brigadier General Sir Capel Holden); Royal Aeronautical Society (Lieutenant-Colonel Mervyn O'Gorman); Society of British Aircraft Constructors, Limited (Sir Henry White Smith). Mr. F. G. L. Bertram, Secretary, Air Ministry. Arrangements have also been made for consultation, when required, with representatives of the Dominions. The Secretary of State has decided to refer to the Advisory Board, as the first subject upon which he desires its recommendations, the question of the cost and practicability of an Imperial Air Mail Service. The Advisory Board held its first meeting on Thursday afternoon, March 2.

SOCIETY OF GLASS TECHNOLOGY.

THE fiftieth meeting of the Society of Glass Technology was held in the College of Technology, Manchester, on February 15, the president, Dr. M. W. Travers, F.R.S., being in the chair. In directing the attention of members to the fact that the society was meeting for the fiftieth time, the president said that from small beginnings at the end of 1916, the society had steadily increased its activities and membership. The number of members now exceeded 650, drawn from various parts of the world, about 100 being American. He hoped that when the society celebrated its one hundredth meeting it would be able to report a continued increase in its usefulness and prosperity.

The first part of the programme at the meeting was devoted to a consideration of a paper by Mr. F. W. Hodkin, B.Sc., and Professor W. E. S. Turner, D.Sc., entitled "*The Relative Advantages and Disadvantages of Limestone, Burnt Lime and Slaked Lime as Constituents of Common Glass Batches containing Soda-Ash and Salt-cake.*" Part II. In presenting this paper, Professor Turner said it was the continuation of a paper given at a former meeting of the society. The conclusions were that the rates of melting depended upon a number of conditions, such as the form of alkali and lime used, and the relative amounts of lime and soda used. In the case of glass such as that used for bottles made on automatic machines, and containing about 8 per cent. of lime, the soda ash burnt lime batch appeared to be the most readily melted. With lime-containing glasses, the melting could be assisted considerably by the addition of small amounts of other oxides, particularly by the addition of magnesia. In the case of glasses containing about 12 per cent. of lime, the slaked lime containing batches, in general, melted most readily. A discussion followed the paper, to which contributions were made by Messrs. W. J. Rees, G. Simpson, A. S. Giles and F. G. Clark. Mr. Hodkin and Professor Turner replied.

The remainder of the meeting was taken up with a discussion of the subject of "*The Melting of Glass.*" A number of questions on the subject had been submitted by members, and formed the basis of the discussion; this being continued from the Leeds meeting in November, 1921, at the general request of members. The questions discussed were: What is the objection to using a large quantity of cullet? What are the troubles it is likely to cause? If there are any, then what is the safe maximum proportion of cullet to batch? What is the procedure to adopt in order to ascertain the homogeneity of the glass, and (*a*) is it better to fill into the furnace batch and cullet separately, or batch and cullet mixed? (*b*) Is it better to fill into the furnace, batch and cullet by the use of a crane-filling shovel through the charging door and distribute them over as great an area as possible, or through the dog-house filled by the overhead batch hopper? For a window glass averaging 73 per cent. silica, 14 per cent. lime, 13 per cent. soda, are their different physical properties, viscosities, difficulties in handworking, due to the nature of batch, either soda-ash or saltcake? Should window glass made with soda ash be inferior to window glass made with saltcake or less workable in glass gathering? It would seem apparent that the use of soda-ash as constituent of the batch is more efficient as to the life of the tank blocks and also to the clouding of the window glass cylinders reheated in the furnace flame containing sulphur from saltcake, and consequently worthy of commendation? How long prior to working should a melt be maintained at "plaining" temperature once it is already plain?

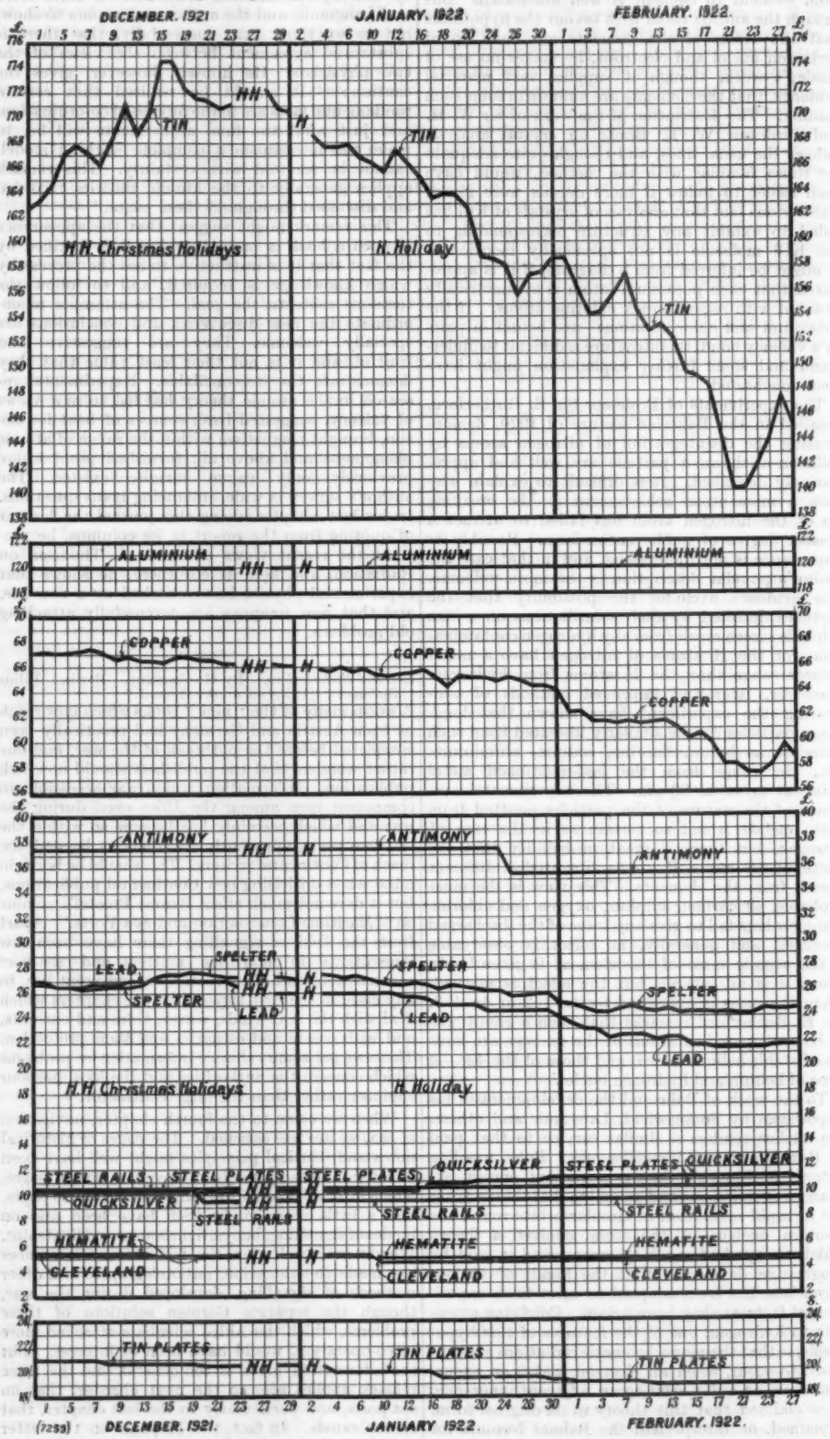
Those contributing to the discussion were: The president, Messrs. W. R. Barker, J. H. Bickerton, Wm. Butterworth, F. G. Clark, J. Connolly, A. S. Giles, P. Haller, F. W. Hodkin, G. Simpson, V. H. Stott, Professor W. E. S. Turner, and Duncan Webb, Junior.

MEETING THE EFFECTS OF THE DROUGHT IN ITALY.—The Fiat Motor Factory, Turin, is run practically entirely by electricity generated by water power from the Alps. The power station for this purpose has been erected in the Alps by the Fiat Company, and the excess power not used by the Fiat works provides lighting for the City of Turin. The factory was recently faced with an entire absence of power owing to last summer's drought. The situation looked serious, but was ingenuously met by distributing throughout the entire works a number of Fiat agricultural tractors connected by belts to the line shafting, these tractors completely superseded the usual electric plant, and proved so satisfactory in every respect that the output from the factory was in no way curtailed by the drought. Large numbers have been sold throughout the entire northern part of Italy for similar use in other engineering plants.

PERSONAL.—Owing to the growth of their business, Messrs. Reavell and Co., Limited, of Ranelagh Works, Ipswich, have moved their London office to larger premises at 47, Victoria-street; their telephone number, "5935 Victoria," remains as before. The head office still remains at Ranelagh Works, Ipswich.—The Considère Construction Company, Limited, who for the past fourteen years have developed in the British Isles the Considère System of reinforced concrete design, propose pooling resources with the French firm of Pelnard-Considère and Caquot, with a view to increasing the scope of their business and giving their English clients the benefit of the unique experience which their French colleagues have had during the past few years. Reinforced concrete work in France has been developed to an enormous extent, and Messrs. Pelnard-Considère and Caquot have themselves designed reinforced concrete work to the value of well over 4,000,000*l.* in the past eight years, covering power stations, bridges, industrial and other buildings, &c.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

THE RAPID CALCULATION OF FERRO-CONCRETE BEAMS.

By AUGUSTE ESNOUF, A.C.G.I., and LEON JOSEPH COUTANCEAU, A.C.G.I., A.M.I.C.E.

(*Concluded from page* 223.)

Examples taken from Bridge Practice. III.

Bridge of clear span of 20 ft. Given centre to centre of beams. Required to design beams A, B, C, Fig. 18, for a mixture of 3 : 6 : 12

Calculated bending moment on :

	Ft./Lb.
(1) Slab ... ... =	2,408
(2) Beam A ... ... =	73,047
(3) Beam B ... ... =	93,748
(4) Beam C ... ... =	124,670

1. *Design of Slab.*—From Table II, page 194 *ante*, for a mixture of 3 : 6 : 12, as for slabs $b = 1$ ft., and as M = 2,408 ft.-lb. :

$$c' = h = \sqrt{\frac{M}{75 \cdot 77}} = \sqrt{\frac{2,408}{75 \cdot 77}} = 5\tfrac{5}{8} \text{ in.}$$

We will take $c = 6\frac{3}{8}$ in., and cross-sectional area of steel is given by :

$$S = 0 \cdot 0008536 \frac{M}{h} = 0 \cdot 0008536 \times \frac{2,408}{5\frac{5}{8}} = 0 \cdot 364 \text{ sq. in}$$

Taking $\frac{1}{2}$ in. diameter rods of section 0·1963 sq. in., we will place them at intervals of $\frac{0 \cdot 1963}{0 \cdot 364} \times 12$ in. = $6\frac{1}{2}$ in., say.

For distributing rods $S_1 = \frac{S}{2} = 0 \cdot 182$ sq. in.

Taking $\frac{1}{4}$ in. rods of section 0·0767 sq. in., we will place them at intervals of $\frac{0 \cdot 0767}{0 \cdot 182} \times 12$ in. = 5 in., say.

2. *Designs of Beam A.*—We have :

$$M = 73,047 \text{ ft./lb.}; \; c = 6\tfrac{3}{8} \text{ in.}; \; b = \tfrac{2}{3} c + \frac{a}{2}$$

or

$$b = \tfrac{2}{3} \times 4\tfrac{1}{8} + \frac{8}{24} = 2 \text{ ft., say,}$$

$$\therefore \frac{M}{b c^2} = \frac{73,047}{2 \times (6\frac{3}{8})^2} = 900$$

From Table I, page 156 *ante*, when :

$$\frac{M}{b c^2} = 900, \; \frac{h}{c} = 3 \cdot 45$$

$$\therefore h = 3 \cdot 45 \times 6\tfrac{3}{8} = 22 \text{ in.};$$

and the corresponding cross-sectional area of the steel is given by :

$$S = 0 \cdot 0008534 \frac{M}{h} = 0 \cdot 0008534 \times \frac{73,047}{22} = 2 \cdot 83 \text{ sq. in.}$$

3. *Design of Beam B.*—We have :

$$M = 93,748 \text{ ft./lb.}; \; c = 6\tfrac{3}{8} \text{ in.}; \; b = \tfrac{2}{3} c = \tfrac{2}{3} \times \frac{13}{3} = 3 \cdot 25 \text{ ft.}$$

$$\therefore \frac{M}{b c^2} = \frac{93,748}{3 \cdot 25 \times (6\frac{3}{8})^2} = 710$$

Looking at Table I, we see that the superior limits for $\frac{M}{b c^2}$ start at 838, which is greater than our calculated $\frac{M}{b c^2} = 710$. Looking, then, at the inferior limits for $\frac{M}{b c^2}$ we see that $\frac{M}{b c^2} = 710$ when $\frac{h}{c} = 8 \cdot 35$, or when $h = 8 \cdot 35 \times 6\frac{3}{8}$, *i.e.*, when $h = 53\frac{1}{4}$ in.

This means that when $h = 53\frac{1}{4}$ in. the neutral axis is just on the point of leaving the slab, or that $y = c = 6\frac{3}{8}$ in. With less than this depth $h = 53\frac{1}{4}$ in., the neutral axis will be in the slab.

For symmetry with the other beams we will take $h = 22$ in., and calculate the $\frac{M}{b h^2}$ from Table II, when we will have :

$$\frac{M}{b h^2} = \frac{93,478}{3 \cdot 25 \times (22)^2} = 59 \cdot 7$$

and for

$$\frac{M}{b h^2} = 59 \cdot 7, \; \frac{h}{y} = 3 \cdot 7 \text{ from Table II.,}$$

or $y = \frac{22}{3 \cdot 7} = 5 \cdot 95$ in., *i.e.*, the neutral axis is inside the slab, and the corresponding working stress of concrete = 482 lb./in., whilst the corresponding tensile reinforcement is :

$$S = 0 \cdot 0008441 \frac{M}{h} = 0 \cdot 0008441 \times \frac{93,748}{22} = 3 \cdot 59 \text{ sq. in.}$$

4. *Design of Beam C.*—We have : M = 124,670 ft./lb.

$$b = \tfrac{2}{3} c = \tfrac{2}{3} \times \frac{13}{3} = 3 \cdot 25 \text{ ft.}; \; c = 6\tfrac{3}{8} \text{ in.}$$

$$\therefore \frac{M}{b c^2} = \frac{124,670}{3 \cdot 25 \times (6\frac{3}{8})^2} = 944.$$

From Table I, when

$$\frac{M}{b c^2} = 944, \; \frac{h}{c} = 3 \cdot 55.$$

i.e., $h = 3 \cdot 56 \times 6\frac{3}{8} = 23$ in., say,

Fig. 18.

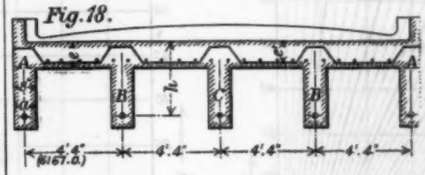


Fig. 19.

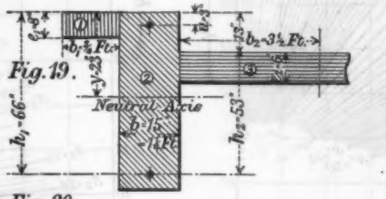


Fig. 20.

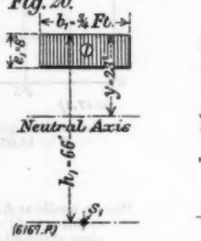


Fig. 21.

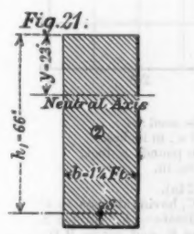


Fig. 22

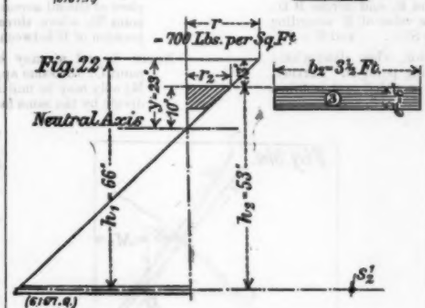
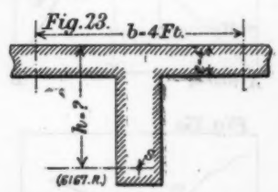


Fig. 23.



The corresponding tensile reinforcement is given by :

$$S = 0 \cdot 0008529 \frac{M}{h} = 0 \cdot 0008529 \times \frac{124,670}{23} = 4 \cdot 61 \text{ sq. in.}$$

Example IV.

Bridge 70 ft. clear span. Single way designed for a travelling load consisting of a four-wheeled wagon of 16 tons.

The main girder of that bridge is as shown in section Fig. 19, and has to resist a bending moment due to the dead and live load of 1,576,230 ft.-lb. Find the necessary steel reinforcement when the mixture chosen for the bridge is 4 : 6 : 12.

In order to find the steel reinforcement required for that girder, it will be found convenient to divide it into three separate beams as is shown by the shading in Fig. 19. Once this is done, find what bending moment each part of that beam can take. If this is greater than the calculated bending moment, the girder has to take, well and good ; if not, compressive reinforcement will be required.

We will first find the position of the neutral axis For a mixture of 4 : 6 : 12 (Table II)

$$y = \frac{h_1}{2 \cdot 86} = \frac{66}{2 \cdot 86} = 23 \text{ in.}$$

1. *Design of Beam* 1. (Fig. 20.). Now :

$$h_1 = 66 \text{ in. and } c_1 = 8 \text{ in.}$$

$$\therefore \frac{h_1}{c_1} = \frac{66}{8} = 8 \cdot 25$$

From Table I, when

$$\frac{h}{c} = 8 \cdot 25, \; \frac{M_1}{b_1 c_1^2} = 4,505$$

$$\therefore M_1 = 4,505 \, b_1 c_1^2 = 4,505 \times \tfrac{3}{4} \times 64$$

$$= 216,240 \text{ ft./lb.}$$

and the corresponding steel reinforcement is given for $\frac{h}{c} = 8 \cdot 25$ by :

$$S_1 = 0 \cdot 000814 \frac{M_1}{h_1} = 0 \cdot 000814 \times \frac{216,240}{66} = 2 \cdot 67 \text{ sq. in.}$$

2. *Rectangular Beam.* (Fig. 21) :

From Table II, for a mixture of 4 : 6 : 12

$$\frac{M}{b h_1^2} = 108.$$

or

$$M = 108 \, b \, h_1^2 = 108 \times \tfrac{3}{4} \times 66 \times 66$$

$$= 588,060 \text{ ft./lb.}$$

The corresponding steel reinforcement is given by :

$$S = 0 \cdot 0008694 \frac{M}{h} = 0 \cdot 0008694 = \frac{588,060}{66} = 7 \cdot 75 \text{ sq. in.}$$

3. *Design of Beam* 3 (Fig. 22).—In this case, however, we should notice that the top fibre A B does not work at a stress of $r = 700$ lb. in.^{2}, but at a rate of r_2, where $r_2 = \frac{30}{23} \times 700 = 304 \cdot 35$ lb./in.^{2}.

Also :

$$\frac{h_2}{c_2} = \frac{53}{6} = 8 \cdot 8.$$

From Table I we have for $\frac{h}{c} = 8 \cdot 8$

$$r_2 = \frac{M'_2}{b_2 c_2^2} A + B = \frac{M'_2}{b_2 c_2^2} \times 0 \cdot 1,276 + 76 \cdot 77.$$

or

$$M'_2 = \frac{b_2 c_2^2}{0 \cdot 1276} (r_2 - 76 \cdot 77)$$

$$= \frac{7}{2} \times \frac{36}{0 \cdot 1276} (304 \cdot 35 - 76 \cdot 77) \text{ ft./lb.}$$

or

$$M'_2 = 224,630 \text{ ft./lb.}$$

And

$$S'_2 = 0 \cdot 0008112 \frac{M'_2}{h_2} = 0 \cdot 0008112 \times \frac{224,630}{53} = 3 \cdot 44 \text{ sq. in.}$$

We have thus found the following bending moments this girder can take without compressive reinforcement, and they are :

M_1 =	216,240	ft./lb.
M =	588,060	,,
M'_2 =	224,630	,,
$M_1 + M + M'_2$ =	1,028,930	ft./lb.

But the bending moment our beam has to take is :

$$M = 1,576,230 \text{ ft./lb.}$$

$$\therefore M_2 = (1,576,230 - 1,028,930) = 547,300 \text{ ft./lb.}$$

is the bending moment which has to be taken by the compressive reinforcement.

Let the compressive reinforcement be placed at a distance $u = 3$ in. from the top of the beam, so that :

$$\frac{h_1}{u} = \frac{66}{3} = 22.$$

Then, from Table III, page 222 *ante*, R'=7,308 lb./in.^{2} and the compressive reinforcement required is

$$S' = 0 \cdot 00172 \frac{M_2}{h_1} = 0 \cdot 00172 \times \frac{547,300}{66} = 14 \cdot 27 \text{ sq. in.}$$

The additional tensile reinforcement is given by :

$$S_2 = 0 \cdot 0008046 \frac{M_2}{h_1} = 0 \cdot 0008046 \times \frac{547,300}{66} = 6 \cdot 67 \text{ sq. in.}$$

For this girder, in order that it could take a bending moment of 1,576,230 ft.-lb., it would require tensile reinforcement of :

$$S = (S_1 + S + S'_2 + S_2) = (2 \cdot 67 + 7 \cdot 75 + 3 \cdot 44 + 6 \cdot 67)$$

$$= 20 \cdot 53 \text{ sq. in.}$$

and compressive reinforcement equal to

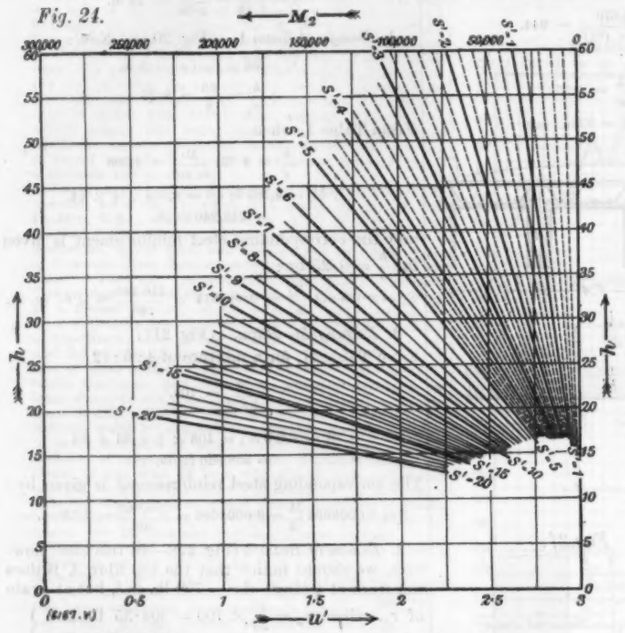
$$S' = 14 \cdot 27 \text{ sq. in.}$$

Example V.

A T-beam having to resist a bending moment of

THE RAPID CALCULATION OF FERRO-CONCRETE BEAMS.

Fig. 24.



Constants adopted:—
R = 15,624 lb. per sq. in.
r = 700 lb. per sq. in.
m = 12.

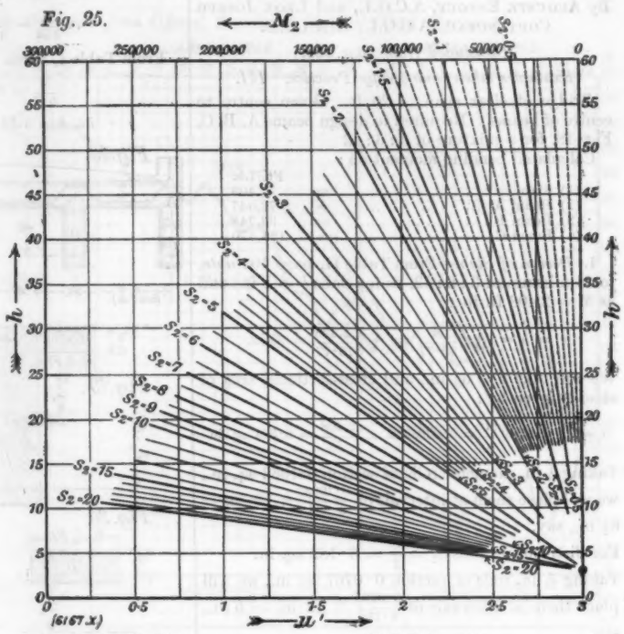
Units to be used:—
h and u', in inches.
M_2, in pounds × foot.
S, in sq. in.

Method of Using this Diagram (see Fig. 24a).

Set a needle at A and one at B. Determine (at sight) point C, having abscissa = u' ordinate = h; and point D, having abscissa = M_2, ordinate = h. Stretch a piece of thread across C A, round A, along A B, round B, and across B D; note point E, where thread intersects itself and estimate value of S′ according to position of E between two consecutive isosideric lines S′= . . . and S′= . . .

NOTE.—h and u' may be multiplied by any common factor, when determining point C; the same applies to h and M_2, when determining point D. Further, M_2 only may be multiplied by any convenient factor, provided care is taken to divide by the same factor the value found for S′.

Fig. 25.



Constant adopted:—
R = 15,624 lb. per sq. in.

Units to be used:—
h and u', in inches.
M_2, in pounds × foot.
S_2, in sq. in.

Method of Using this Diagram (see Fig. 25a).

Plant a needle at A and one at B. Determine (at sight) point C, having abscissa = u', ordinate = h; and point D, having abscissa = M_2, ordinate = h. Stretch a piece of thread across C A, round A, along A B, round B and across B D; note point E, where thread intersects itself, and estimate value of S_2 according to position of E between two consecutive isosideric lines, S_2 = . . . and S_2 = . . .

NOTE.—h and u' may be multiplied by any common factor, when determining point C; the same applies to h and M_2, when determining point D. Further, M_2 only may be multiplied by any convenient factor, provided care is taken to divide by the same factor the value found for S_2.

42,752 ft.-lb., is as shown in the section (Fig. 23). Find its depth and necessary reinforcement?

Mixture is 3 : 6 : 12.

$$\frac{M}{b\,e^2} = \frac{42{,}752}{4 \times 16} = 668.$$

By looking at the inferior limits of $\frac{M}{b\,e^2}$ we see that the lowest figure for that mixture is 837·64. This tells us at once that the neutral axis of that beam for that bending moment falls inside the slab.

Looking, then, at the inferior limits of $\frac{M}{b\,e^2}$ we see that for a ratio of $\frac{h}{e} = \frac{h}{y} = 10$, the lowest figure is 6·99.

Besides, by what has been shown in the theory of concrete beams when

$$\frac{h}{e} = \infty \; ; \; \frac{M^*}{b\,e^2} = 651,$$

so that if we wanted to know at what depth of the beam the neutral axis would leave the slab, we would have the relation:

$$\frac{M}{b\,e^2} = 668 = \frac{R\,(3\,i-1)}{6\,m\,(i-1)} = \frac{217\,(3\,i-1)}{(i-1)}$$

where $i = \frac{h}{e} = \frac{h}{y} = 26{\cdot}53$, so that $h = 26{\cdot}53 \times 4 = 106$ in.

But we cannot for that particular case construct such a deep beam, and it is required that the beam should be as shallow as possible.

For a mixture of 3 : 6 : 12, the shallowest beam we can construct will have a ratio of $\frac{h}{e} = 3{\cdot}325$, or 13·3 in. We have taken for that beam $h = 15$ in.

We have, then,

$$\frac{M}{b\,h^2} = \frac{42{,}752}{4 \times 225} = 47.5.$$

* When $\frac{h}{e} = \infty$; $\frac{M}{b\,e^2} = \frac{R}{2\,m} = \frac{15{,}624}{2 \times 12} = 651$.

Fig. 24a.

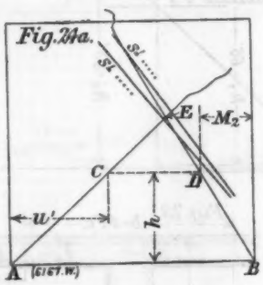
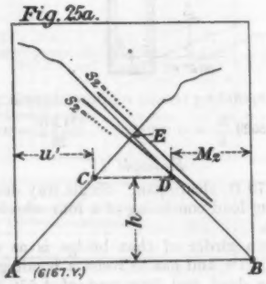


Fig. 25a.



By looking at Table II, for such a beam, when $\frac{M}{b\,h^2} = 47{\cdot}5$ in.

$$\frac{h}{y} = 4{\cdot}1 \text{ or } y = \frac{15}{14{\cdot}1} = 3{\cdot}67 \text{ in.}$$

its corresponding $r = 420$ lb./in.², and its corresponding steel reinforcement is:

$$S = 0{\cdot}000836\,\frac{M}{h} = 0{\cdot}000836 \times \frac{42{,}752}{15}$$
$$= 2{\cdot}38 \text{ sq. in.}$$

APPENDIX.

An approximate linear equation replacing the quadratic equation on page 155 *ante* is:

$$\frac{M}{b\,e^2} = r\,i - \frac{R + 2\,m\,r}{2\,m} + \frac{1}{i} \cdot \frac{R + m\,r}{3\,m}$$

Making use of the method described by Mr. Esnouf in his paper on "Approximate Equations," read at a meeting of the "Mauritius Old Centralians," the following rectilinear equation is obtained:

$$i = \frac{\frac{M}{b\,e^2}}{0{\cdot}984\,r - 0{\cdot}0157\,\frac{R}{M}} + \frac{0{\cdot}856\,r + 0{\cdot}356\,\frac{R}{M}}{0{\cdot}984\,r - 0{\cdot}0157\,\frac{R}{M}}$$

the relative error in the value of i, as compared with the exact value obtained from the quadratic equation is always on the safe side, and its maximum value is:

$$\frac{0{\cdot}005\,r + 0{\cdot}0046\,\frac{R}{m}}{0{\cdot}984\,r - 0{\cdot}0157\,\frac{R}{m}}$$

Introducing in these expressions the values of r, R and m used throughout this paper, they become:

(1) For $r = 700$ lb./in.², $i = 0{\cdot}0015\,\frac{M}{b\,e^2} + 1{\cdot}59$

Maximum relative error = 0·0142 or less than 1½ per cent.

(2) For $r = 560$ lb./in.², $i = 0{\cdot}00188\,\frac{M}{b\,e^2} + 1{\cdot}78$

Maximum relative error = 0·0165 or just over 1½ per cent.

Fig. 25 affords by means of co-linear co-ordinates a very direct method of determining S′ when M_2, h and u are known, or *vice versa*; it represents in a different way part of Table III.

Figs. 25 and 25*a* are very similar to Figs. 24 and 24*a*, and afford the means of determining S_2 when M_2, h and u are known. They represent that part of Table III which is not covered by Fig. 24.

THE STILL ENGINE FOR M

CONSTRUCTED BY THE SCOTTS' SHIPBUILDING AND E

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Fig. 1.

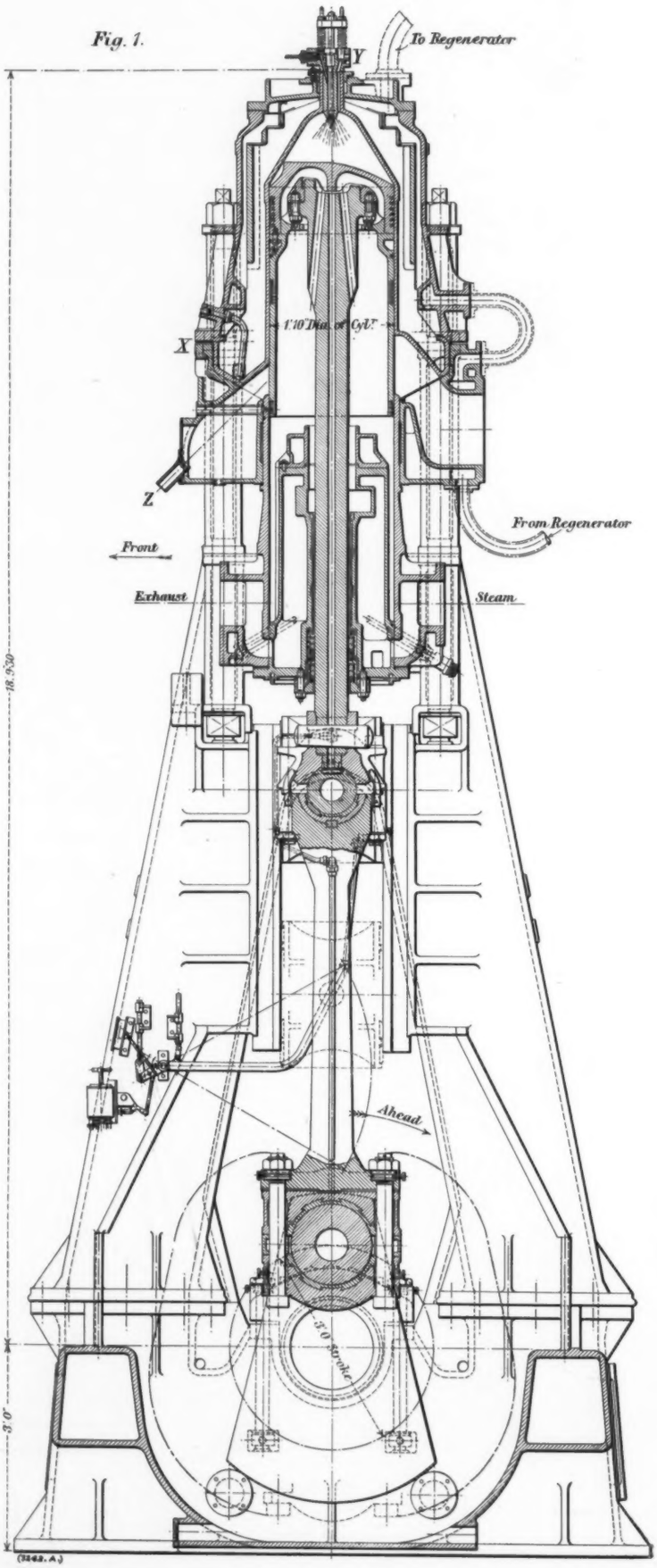


Fig. 3. PISTON HEAD RIBBING.

Fig. 4. COMBUSTION CYLINDER RIBBING.

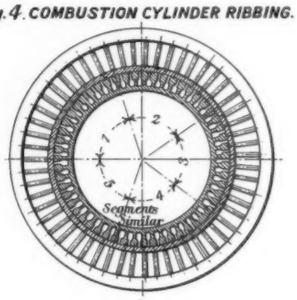


Fig. 5. EXHAUST PORTS & STEAM CYL^{R} CASTELLATIONS.

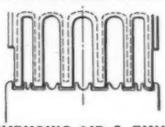


Fig. 6. SCAVENGING AIR & EXHAUST BELT.

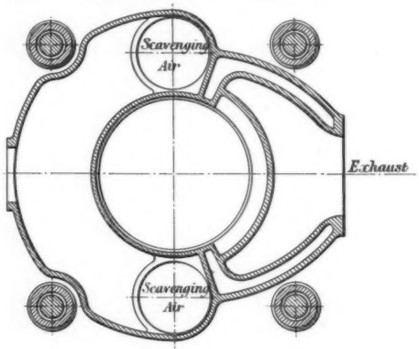


Fig. 7. COVER SHOWING VALVES & STEAM CYL^{R}

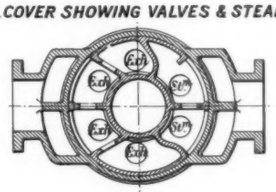
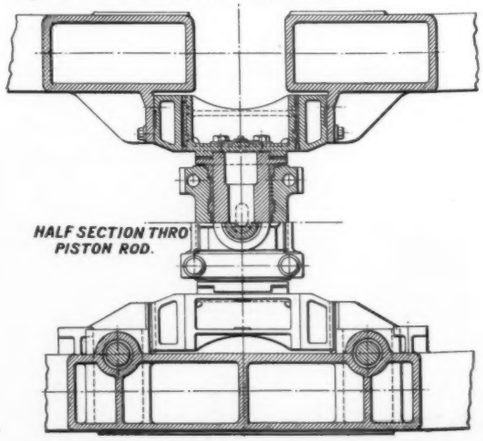


Fig. 8. HALF SECTION THRO' GUDGEON PIN.



E FOR MARINE PROPULSION.

LDING ND ENGINEERING COMPANY, LIMITED, GREENOCK.

Description, see Page 275.)

Fig. 2.

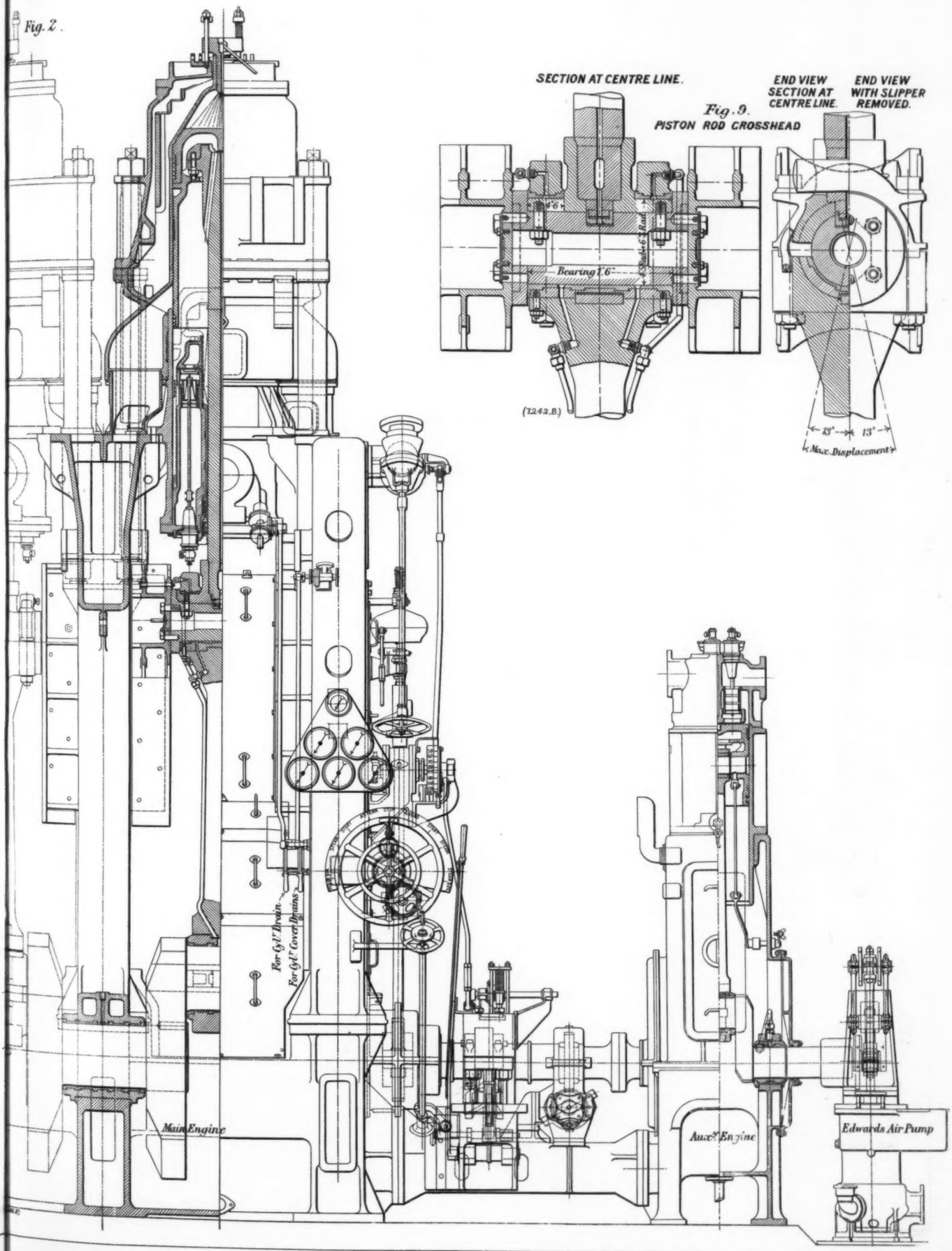


Fig. 9.

PISTON ROD CROSSHEAD

THE STILL ENGINE FOR MARINE PROPULSION.*

By ARCHIBALD RENNIE.

THE principles upon which an engine constructed on the Still system operates are presumed by this time to be fairly well known. An informative paper on this aspect of the subject was read before the Royal Society of Arts, London, in 1919, by Captain Frank E. D. Acland;† and various articles bearing upon it have appeared from time to time in the technical journals. It will be sufficient, therefore, to say here that the fundamental principle is the recovery of heat from the waste products of combustion, and the utilisation of that heat in the engine itself for the development of power. This heat is recovered and converted into power through the medium of steam. The transfer of heat from the waste gases to the steam generating system takes place in the combustion cylinder and in a regenerator and feed-water heater.

An engine operating on the Still system may, therefore, be described quite accurately as a combined internal-combustion and steam engine, and may be applied, either as an oil or gas engine, to almost any case in industry where power is required and liquid or gaseous fuel is obtainable. The system may be applied also, with equal facility, to engines designed to work on the four-stroke and two-stroke principles, including all the sub-divisions of these two general types of internal-combustion engines to be met with in practice.

In this paper, however, attention will be directed to an engine of the single-piston type which works on its combustion (or top) side upon the two-stroke port scavenging principle, and employs airless (solid) injection for the fuel oil; and on its steam (or bottom) side operates upon the single-acting principle, further economy being obtained by compounding the cylinders of one or more groups on the steam side, as described hereafter. Both these functions occur once per revolution, the steam side being 180 deg. of crank angle behind the oil side, so that the engine is double-acting in its operation, with this limitation, however, that the power developed on the steam side is considerably less than that developed on the oil side. Another important point of difference to be noted is that, whereas in all other oil engines of reasonably large powers oil or water is circulated to the pistons for cooling purposes, in the Still engine this function is performed by the operating steam, which in any case is passing through the cylinder, and in keeping the piston cool the steam itself tends to become superheated, thus reacting beneficially on the efficiency of the steam cycle.

Compared with other oil engines, it may be said of the Still engine that steam, generated from oil burned in the regenerator, displaces compressed air for starting and manœuvring purposes. When, however, these operations are completed, the Still engine presents this important advantage, that steam continues to be generated from the waste heat of combustion alone, and is utilised in the cylinders for the continuous production of power, thus adding energy without adding to the fuel cost.

Aim in Design.—In considering the construction of a full-size experimental unit for marine purposes, it was decided that the engine should be of such dimensions as would cover a range of power varying from about 700 b.h.p. to 7,000 b.h.p., with single or twin-screws, and a reasonable number of cylinders. Consideration of revolutions, mean effective pressure, and other factors ultimately resulted in a cylinder of 22 in. diameter and 36 in. stroke being adopted as the most suitable. Such an engine running at a speed of 120 r.p.m. was estimated to give a normal brake horse-power of 350 in one cylinder at maximum efficiency, and an overload of about 400 b.h.p. A single-cylinder two-stroke experimental engine of this size was, therefore, proceeded with, the crankshaft and bedplate being made of such dimensions as would be suitable for six cylinders of this size in line. As, however, it was considered desirable to work the experimental engine on the compound principle on its steam side, so that its working conditions might approximate as closely as possible to those which will obtain in a multi-cylinder engine on board ship, a small independent single-acting high-pressure steam engine with a cylinder of 14 in. diameter and 22 in. stroke was also constructed and coupled direct to the main engine crankshaft. The cranks of the two cylinders are arranged at the same angle relative to the dead centres, so that the pistons move up and down together. By this arrangement the steam side of the main or combustion cylinder which forms the low-pressure stage is ready to take steam just as the high-pressure cylinder begins to exhaust. The steam supplied to the high-pressure engine under normal running conditions is, of course, only that generated by the waste heat from the single combustion cylinder.

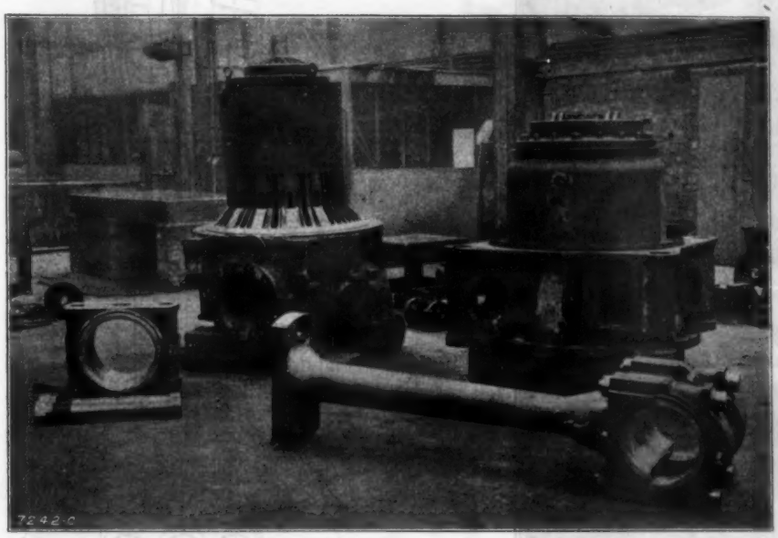


FIG. 10. MANTLE CYLINDER, LINER AND CONNECTING ROD.

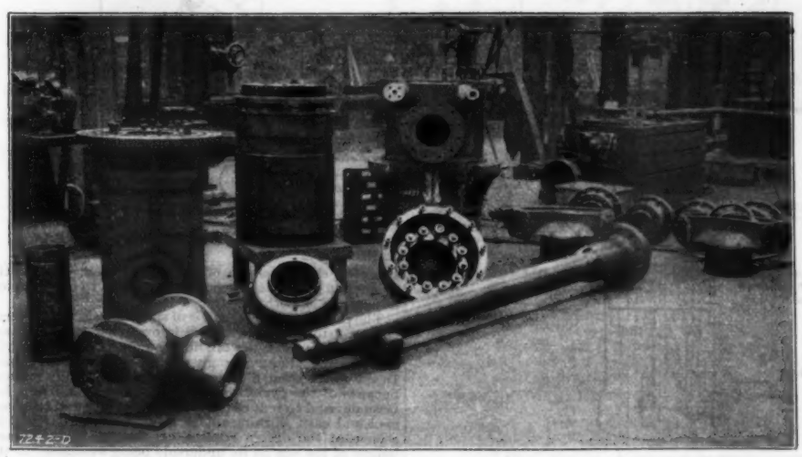


FIG. 11. STEAM CYLINDER AND COVER; PISTON HEAD AND SKIRT; PISTON ROD AND CROSSHEAD; AND SCAVENGING AIR INLET PIPES.

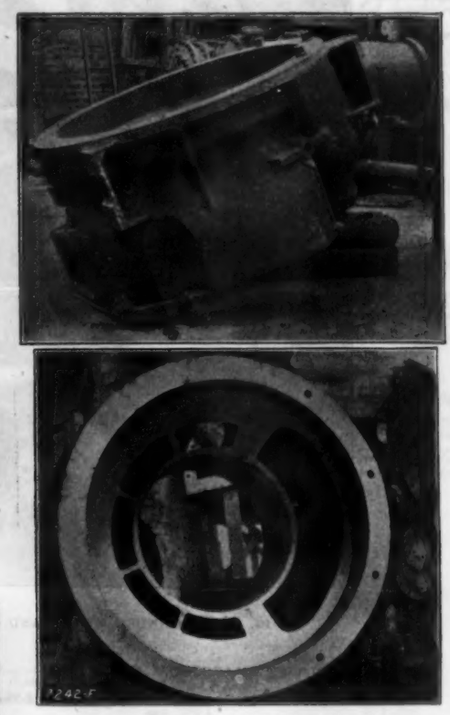


FIG. 12. SCAVENGING AND EXHAUST BELT.

Design and Construction.—Turning now to the general arrangement and details of this experimental engine, as shown in Figs. 1 to 8, Plate XIV, it will be seen that the framework calls for no special remark, excepting perhaps the columns. These are A-shaped looking in a fore and aft direction, and are, in fact, simple front and back columns cast together. The guides are of the double-slipper type, but split, and have one-half carried by each column. This arrangement admits of the adoption of the special design of crosshead to be referred to shortly, and gives ready access to the engine both front and back. It also allows of the easy removal of the steam cylinder cover when desired. The spaces between the columns, front and back, and between the legs of each column are closed with portable doors.

The combustion cylinder, which in its completed state may be said to consist of three parts, namely, the working liner, the outer mantle, and the scavenging and exhaust belt, is supported from the columns by four distance pieces through which large steel bolts are passed, having their upper ends secured to the mantle and their lower ends let into and secured to the upper part of the columns. These bolts take the combustion load, and transmit it through the columns to the bedplate. The steam and water jacket joints between the liner and mantle are made on the conical face and stuffing-box shown at X and Y, Fig. 1. It will be seen that the working liner by this arrangement is secured at the bottom of its length, and is free within the mantle to adjust itself to changing temperatures. The mantle and belt are also free to adjust themselves independently of the liner. The liner itself is only $\frac{5}{8}$ in. thick in the body. It is ribbed vertically, and its upper half is fitted with steel shrouds shrunk on, to give the necessary strength to resist the bursting pressure due to combustion. Incidentally these shrouds assist the convection currents within the

* Paper read before the Institution of Engineers and Shipbuilders in Scotland, February 14, 1922 (slightly condensed).

† Journal of the Royal Society of Arts, No. 3,472. Vol. lxvii, "A New Prime Mover of High Efficiency and British Origin," by Frank E. Dyke Acland, M.Inst.C.E., May 26, 1919.

jacket to a considerable extent. A sectional plan of the liner is shown in Fig. 4. An important point in the design of the liner, and also of the piston head, is that examination of all the surfaces can be made, there being no hidden internal spaces. The combustion exhaust ports in the lower end of the liner are of special hooded form, and should be noted for the completeness with which they are water cooled. The main idea underlying the design of the Still engine liner is the reduction of the temperature differences, and consequent quite independently of the combustion cylinder, and has complete freedom for expansion. The cover is of deep formation, and is projected well into the cylinder, leaving only a small annulus with sufficient clearance for the piston skirt. The steam and exhaust valves, of which there are two and four respectively of simple piston type, are carried well into the cover head to reduce the steam clearance volume to a minimum, and are directly connected to their operators bolted on the cover flange, see Figs. 2 and 7.

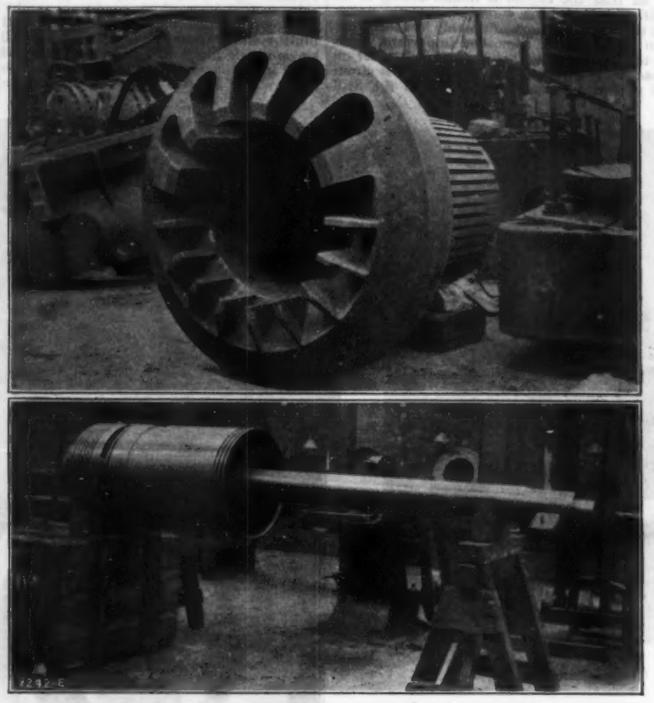


FIG. 13. CYLINDER LINER, AND PISTON AND PISTON ROD.

Fig. 15. **FUEL INJECTION PUMP.**

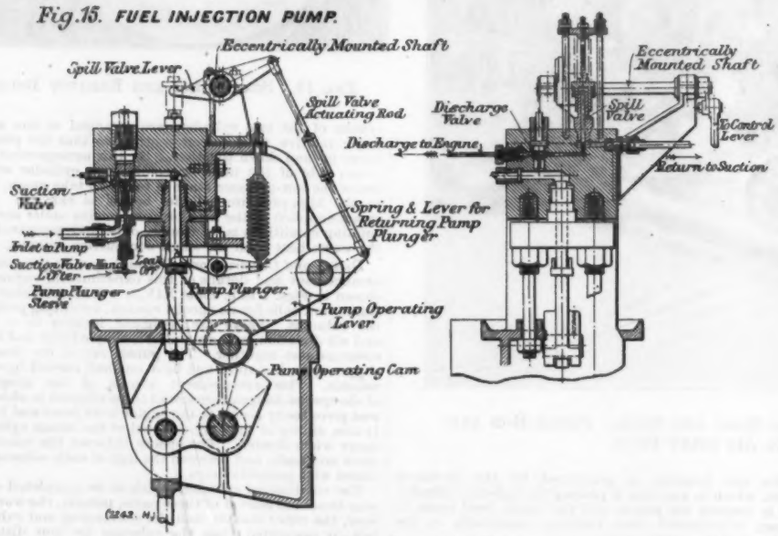


FIG. 15. FUEL INJECTION PUMP.

heat stresses, between its inner and outer walls to the lowest possible minimum, and the provision of ample surface for the rapid transfer of heat to the jacket water. The whole combustion load is taken by the breech end of the liner, and transmitted through the conical joint to the large steel bolts. There is no cylinder cover on the engine in the sense in which a cover is understood in oil-engine practice. The cover shown, fitted to the mantle, takes the steam pressure only, and was provided to facilitate inspection of the water-jacket space. No use has been found for it in this connection, however, and it is proposed to dispense with it in future construction.

The steam cylinder is supported from the columns

Although described separately, the combustion and steam cylinders are component parts of a whole, with a common piston, and where the barrels of the cylinders meet they are formed with a series of fingers, which mesh with each other and overlap for about 1 in., thereby providing ample guiding surface for the piston rings as they pass from one cylinder to the other, see Fig. 5. Oil for piston lubrication is introduced into the cylinder at three points in its circumference.

The piston is made in two parts. The skirt calls for no remark, but the head is spirally ribbed internally, as shown in Fig. 3, to guide the flow of steam over the crown in as long a path as is reasonably possible. At the same time this formation provides the piston with some degree of flexibility, and allows it to adjust itself to temperature conditions without danger of fracturing the ribs. The piston rod is deeply embedded in the piston head with spigot and flange, and the attachment of the two is made by studs and nuts. The piston-rod neck is pierced by six holes for the guidance of the steam to the piston head, and is enlarged in diameter at this part to maintain its strength. These holes, acting in conjunction with the steam valves and ports, convey the steam, during the admission period, into the cylinder by way of the ribbed

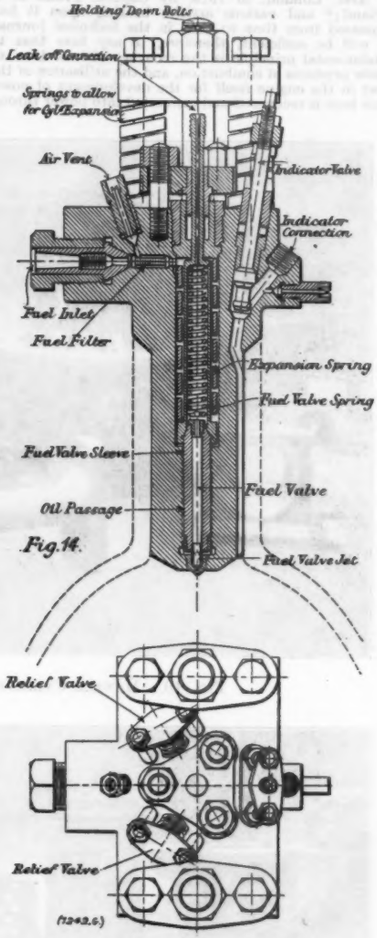


FIG. 14. FUEL INJECTION VALVE.

space on the underside of the piston head, heating the steam and cooling the head in the process to the manifest advantage of both.

The piston-rod crosshead is of special design, and merits careful attention. It is well known that the crosshead bearings of most types of Diesel engines are very heavily loaded, and frequently give trouble from that cause. In the Still engine, although the load is naturally reduced because of the cycle, the design of crosshead shown has been devised to reduce the load still further and to ensure cool and easy working under all conditions. It will be seen that the design admits of the full diameter and length of the pin on its underside being available for the downward combustion load. On its upper side the pin is secured to a saddle, which takes the half-bearings for the upward steam load. This saddle is bossed, and provides for the attachment of the complete crosshead to the piston rod by cotter. In this construction, therefore, the top and bottom bushes work on different bearing diameters, but these being concentric, no real objection can be taken to the design on this account, and in practice the whole bearing works very satisfactorily. The crosshead is illustrated in Fig. 9, Plate XIV, and other details are shown in Figs. 10 to 13, page 275, and above.

Materials.—The materials of construction call for little remark. The mantle and scavenging belt are made of steel castings, and all other parts of usual materials suitable to their position and function on the engine. Special care and attention was given to the composition and casting of the combustion cylinder liner and piston head. Such care, however, is not essential to the Still engine—several units already built and working satisfactorily have liners cast of ordinary grey iron—but in the Scott unit it was decided to follow general oil-engine practice in this matter, and use a composition which experience showed to be suitable for internal-combustion cylinder liners. The composition of the material, therefore, used in the experimental engine is approximately as given in the following table:

	Per Cent.
Graphite	2·4 to 2·5
Combined carbon	0·55 „ 0·65
Silicon	1·5 „ 1·7
Sulphur	0·06 „ 0·07
Phosphorus	0·5 „ 0·6
Manganese	0·75 „ 1·0

some difficulty would be experienced in getting good castings, but such was not the case, satisfactory castings being produced at the first attempt.

Valve-Gear Operation (Oil and Steam).—The whole engine is symmetrical about its fore and aft centre-line in all essentials, so that it runs equally well ahead or astern at any load. The only valves in operation when running are the fuel-injection valve on the combustion side, and the steam and exhaust valves on the steam side. The former is worked automatically by the fuel-injection pressure, and the latter by a system of oil under pressure.

The fuel-injection valve is shown in Fig. 14, and is spring loaded. It is centrally situated in the cylinder head, and carries relief valve and indicator connections in its outer casing. It sits in a conical seat formed on the upper projecting mouth of the combustion cylinder liner, and is secured to the top of the cylinder mantle through heavy springs, which allow of the valve adjusting itself to suit temperature conditions. These springs also allow the complete valve unit to act as a safety valve to the combustion side of the engine.

The fuel-injection pump is shown in Fig. 15, and was first placed at the level of the cylinder head to reduce the length of pipe between the pump and fuel valve to a minimum. In this position it was worked by eccentric and gear from the crankshaft, but these were ultimately dispensed with and the pump fitted down at the crankshaft level, where it is now worked by a cam from the shaft. Here, it may be said, no difference in results has been noticed through the change in position of the pump. The plunger is 1¼ in. in diameter and the stroke 1·3 in. No packing is used, the plunger being simply lapped and made a push fit in the barrel, which is 6 in. in length. The timing of the fuel injection is fixed by the cam, and the period of injection by the spill valve. This spill valve opens from the discharge chamber of the pump, and is worked by the same lever as actuates the pump plunger. Its function is to break the pressure of discharge at the end of the desired injection period and return the spilled oil to the suction again. The sudden and positive break in pressure allows the fuel valve to seat itself quickly, and prevents the formation of drips on the nose of the jet. It also provides a very safe method of injection, as by this "make and break" system there is no pressure in the fuel-injection pipe except during the actual injection period. Hence there can be no question of a leaky fuel-valve permitting the injection of fuel into the cylinder at the wrong period, such as may easily happen with a constant-pressure system. It is to be noted further that the injection of fuel into the cylinder starts at the same point in the stroke

Fig. 16.

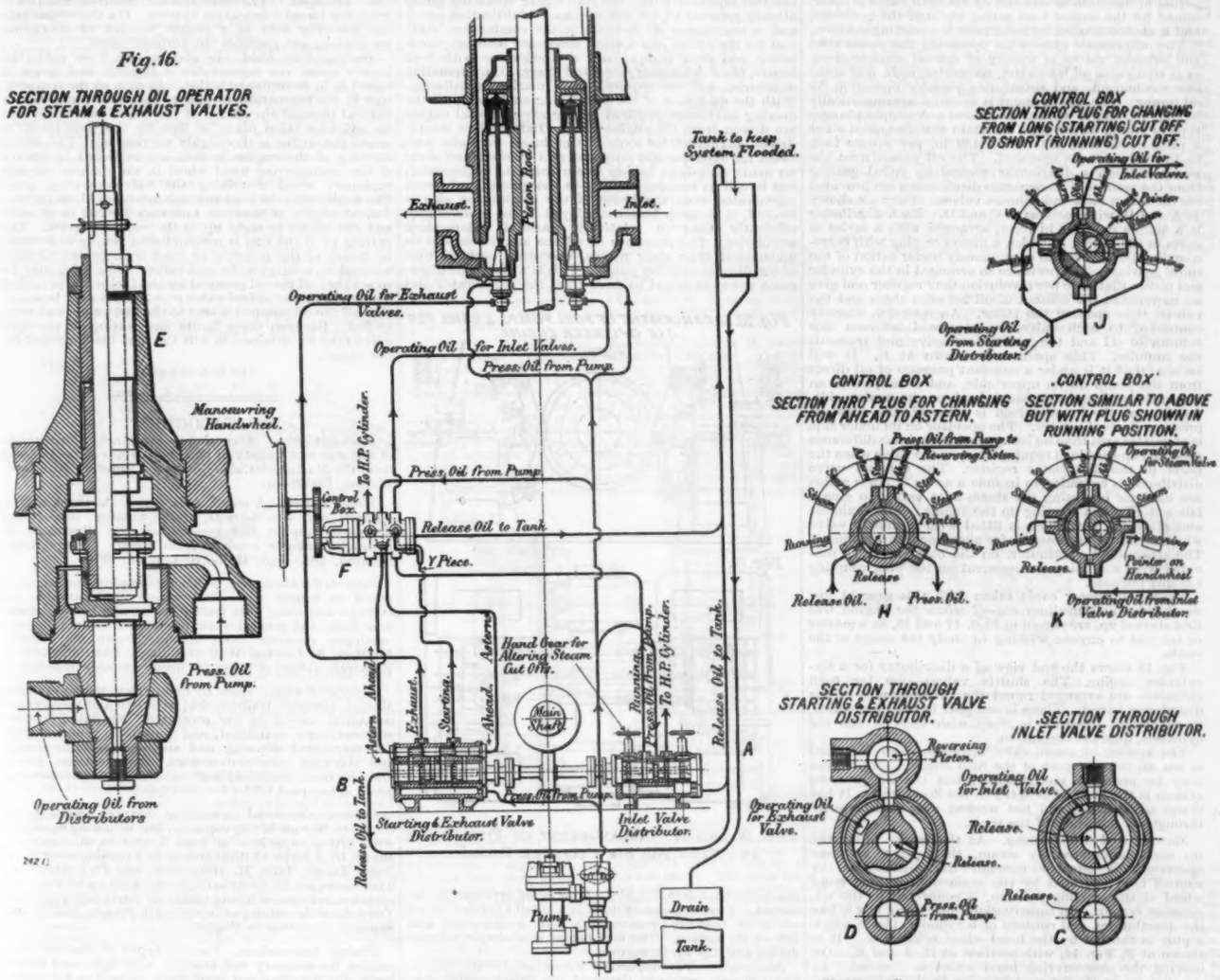


FIG. 16. DIAGRAMS SHOWING OIL OPERATION OF STEAM VALVES AND ENGINE CONTROL.

Fig. 17. Scale ½00

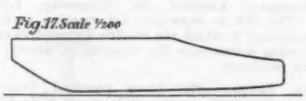
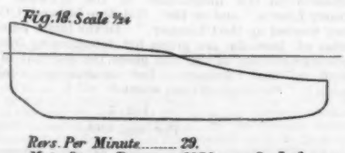


Fig. 18. Scale ½4



Revs. Per Minute ..... 29.
Main Steam Pressure 85 Lbs. per Sq. Inch.
H.P. Receiver ..... 75.
L.P. Receiver ..... 4 to 9 Lbs. per Sq. Inch.
Vacuum ..... 23¼ Inches.

FIGS. 17 AND 18. TYPICAL STEAM CARDS TAKEN AT LOW REVOLUTION.

This material has a tensile strength of about 16 tons per square inch, and retains this strength until a temperature of 750 deg. F. is exceeded. The amount of growth at the working temperatures of the engine is negligible. The Brinell hardness number is 230. Owing to the close ribbing on the cylinder liner and piston head, and the low phosphorus content of the material, it was thought that

Fig. 19.

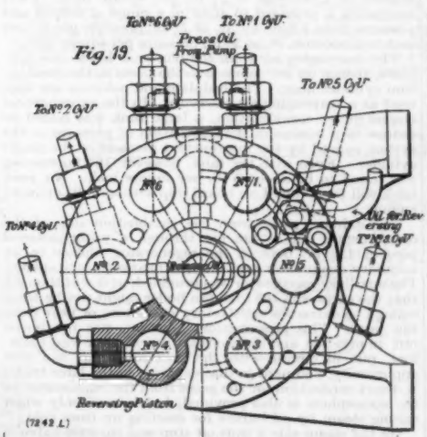


FIG. 19. DISTRIBUTOR FOR SIX-CYLINDER ENGINE.

at any load. The spill-valve action is such that increase of power is obtained by increasing the injection period, which is the ideal condition, and very difficult to attain with cam-operated valves. At normal load the fuel-injection pressure at the valve is about 6,000 lb. per square inch. The spill valve breaks this to atmospheric pressure, so that the pump builds up its pressure between these limits at every stroke. The termination of the period of injection as effected by the spill valve is determined by the engine load acting through the governor, and is also controlled by hand from the starting position.

The oil-pressure system for operating the steam inlet and exhaust valves is worthy of special consideration, as it eliminates all lay-shafts, eccentrics, rods, and such-like mechanism, and substitutes therefor operation by oil power. The arrangement is shown diagrammatically in Fig. 16, and is worked as follows: A simple plunger type of pump, driven from the main shaft, supplies oil at a pressure of from 350 lb. to 450 lb. per square inch to the valves to be operated. The oil passes from the pump through a distributor worked by spiral gearing from the main shaft. Separate distributors are provided for the steam inlet and exhaust valves. They are shown at A and B, with sections at C and D. Each distributor is a simple cylinder in form, arranged with a series of ports in the barrel, in which a piston or plug with corresponding ports revolves continuously under action of the spiral gearing. The ports are so arranged in the cylinder and piston that once per revolution they register and give an impulse to the column of oil between them and the valves, thus opening the latter. An operator, directly connected to each valve, is interposed between this column of oil and the valve, to receive and transmit the impulse. This operator is shown at E. It will be seen that it is under a constant pressure of oil direct from the pump on its upper side, and is subject to an intermittent impulse-pressure load on its under side. As soon as the impulse load is released, the constant pressure closes the valve. The operator on its under side is of greater area than on its upper side, and this difference gives the upward load required to open the valve when the ports in the distributor register. The exhaust valve distributor is extended to include a series of ports which are used for operating the steam-inlet valves to give a late cut-off when starting up the engine. This (exhaust and starting) distributor is fitted with a shuttle valve which is set by oil pressure for ahead or astern running. The steam-inlet distributor, on the other hand, is provided with a slipping arrangement on the plug coupling for this purpose.

Typical indicator cards taken with this gear at low revolutions and medium cut-off when the engine was first started up, are shown in Figs. 17 and 18, as a matter of interest to anyone wishing to study the shape of the cards.

Fig. 19 shows the end view of a distributor for a six-cylinder engine. The shuttle valves—one for each cylinder—are arranged round the circumference of the distributor barrel. There is one port in the plug which, in revolving, registers in turn with each of the six cylinders, once per revolution.

The system of steam-valve operation here described is not an integral part of the Still engine. The valves may be operated mechanically, but the oil pressure system is the method adopted in the Scott unit. It has many advantages, and has worked very satisfactorily throughout the whole of the trials.

Starting and Manœuvring.—As the engine is started up and manœuvred by steam, the control of these operations is effected through the distributors. A control box, operated by the main manœuvring hand wheel at the starting position, is connected to the oil-pressure system. In construction this control box is like the distributors, and consists of a cylinder, inside which a plug is rotated by the hand wheel referred to. It is shown at F, Fig. 16, with sections at H, J and K. On moving the manœuvring hand wheel to "ahead" on the dial, as at H, the shuttle valve in the exhaust and starting distributor is set by the oil pressure for ahead running. Further movement of the hand wheel to the "Starting" position on the dial, as at J, connects the starting end of the distributor to the steam valve operator on the cylinder to give a late cut-off and starts the engine. Further movement of the hand wheel to the "Running" position on the dial, as at K, cuts out the starting steam-distributor, brings in the running steam-distributor with its early cut-off, and puts the engine on fuel oil. Meanwhile the exhaust valves have been operated direct from their own end of the exhaust and starting distributor, without passing their oil through the control box. All these movements of the hand wheel may be carried out in leisurely fashion, and should it be desired to run on steam only, the hand wheel is simply brought to rest at the "Steam" position on the dial. A simple interlooking device is fitted to prevent the engine being run on oil except when the hand wheel is in the "Running" position, and steam is available for piston cooling. "Astern" running is obtained and controlled in exactly the same way as ahead running, by reversing the direction of movement of the manœuvring hand wheel. During the process of starting up and manœuvring, the oil-pressure supply is obtained from an independently-driven stand-by pump.

Reversal of the fuel-pump action is obtained by fitting a separate astern cam and moving the cam roller from one cam to the other. This is done in the single-cylinder engine by hand gear, which is special to that unit. In a multi-cylinder engine the moving of the roller will be effected by the steam-valve oil-pressure system, and will occur at the same time and by the same movement of the manœuvring hand wheel as sets the steam-valve distributors for astern running. The cams are arranged in pairs, and each pair is designed to operate two fuel pumps, one cam being in use when running ahead and the other when running astern. In a six-cylinder engine, therefore, there will be six fuel pumps and six cams—three of the latter for ahead running and three for astern running. Reversal of the direction of rotation is obtained by the steam gear before the fuel pumps come into action. The arrangement for a six-cylinder engine is shown in Figs. 20 and 21.

Auxiliary Machinery.—The auxiliaries required for the working of the experimental engine, in addition to the fuel-injection pump and valve-gear operating pump already referred to, consist of a forced lubrication pump and a scavenging air blower for the combustion side; and for the steam side a small condenser with air, circulating and feed pumps, and a regenerator with feed heater, filter circulating pump and filters. Corresponding auxiliaries will be required in a marine installation. With the exception of the scavenging air blower, all the moving auxiliaries required by the experimental engine are driven from the engine itself. Independent steam-driven auxiliaries for some of the duties were also provided for experimental purposes, and were worked alone on many occasions, taking steam from the regenerator, but it will be recognised that, as the quantity of steam regenerated from the losses of the combustion side is limited, it is much better employed in the main engine efficiently than in relatively wasteful independent auxiliaries. The functions of all the auxiliaries will be understood from their names, excepting perhaps that of the filter circulating pump. This is a simple displacement pump arranged to draw from the regenerator and

Fig. 20. ARRANGEMENT OF FUEL PUMPS & CAMS FOR SIX CYLINDER ENGINE.

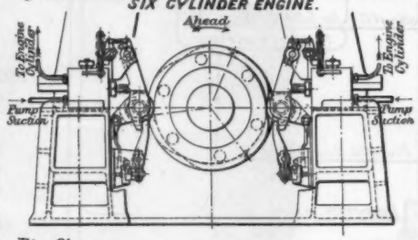
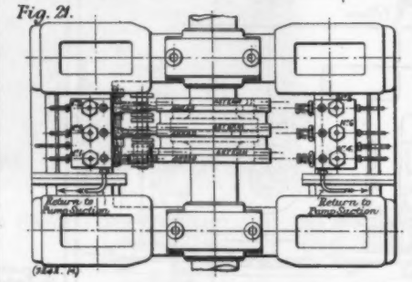


Fig. 21.



FIGS. 20 AND 21. ARRANGEMENT OF FUEL PUMPS AND CAMS FOR SIX CYLINDER ENGINES.

discharge back into it again, a filter being arranged in the circuit. The regenerator itself is a small Cochran boiler of 150 lb. working pressure, 5 ft. 6 in. in diameter, and 300 sq. ft. surface. The feed-heater is of simple tubular design and 228 sq. ft. surface.

Scavenging air is supplied by a small electrically-driven turbo-blower, specially designed for experimental use, having a normal output of 1,500 cub. ft. of free air per minute at a pressure of 2½ lb. per square inch. Field regulation is provided to allow of a range of output and pressure from 1,200 cub. ft. at 2¼ lb. pressure per square inch to 2,000 cub. ft. at 3¼ lb. pressure per square inch.

The scavenging air from the blower is led to the bedplate, thence up the columns to the ports in the combustion cylinder liner. The bedplate and columns are thus used as a scavenging air reservoir. In the experimental engine under consideration, a large tank was added to reduce to a miniumm the fluctuation of pressure in the system caused by the intermittent demand of the single cylinder. Even with the tank, however, the fluctuation was found to be about 5 lb. per square inch. No such tank will be required on board ship with a multi-cylinder engine.

The exhaust gases from the combustion side of the experimental engine are led through a water-jacketed pipe of 12½ in. bore to the regenerator, thence to an auxiliary regenerator and the feed heater to atmosphere. The auxiliary regenerator was provided, as it was thought that the surface in the Cochran boiler might not be large enough to extract a satisfactory maximum of heat from the gases. This presumption, however, was not borne out in practice, and the auxiliary regenerator was, therefore, put in circuit with the feed heater at the first opportunity, and used in that capacity in the later trials. A direct connection for the gases from the regenerator to the atmosphere is also provided, but is used only when raising steam by oil burner for starting up from cold.

On the steam side a shut-off stop and throttle valve is inserted in the main steam pipe from the regenerator. The stop valve is used simply to give control over the steam pressure carried in the regenerator, whilst the throttle valve is connected to the governor. The exhaust steam from the low-pressure cylinder is led to the condenser through a grease extractor.

A governor of the common ball-type is fitted to the engine. It acts through a servo-motor, and controls the setting of the spill valve on the fuel injection pump. It is adjusted by means of a small hand wheel control passing through the centre of the main manœuvring hand wheel, and may be set by this means to control the speed of the engine at any revolutions from about 50 to 130 per minute. Independent hand control of the spill valve is also arranged. The servo-motor receives its power from the forced-lubrication system. On the steam side the governor acts as a simple cut-out at maximum revolution, and operates the throttle valve.

Starting from Cold.—In starting up from cold, the burner under the regenerator is lighted, and steam is raised as in an ordinary boiler. As soon as the temperature in the regenerator begins to rise, it is found that a natural thermal circulation of the water between it and the cylinder takes place, so that by the time steam is raised the engine is thoroughly warmed up. The actual starting of the engine is then accomplished by means of the manœuvring hand wheel in the manner already explained when describing the valve-operating gear. The engine may be kept running on steam alone for any desired length of time, or fuel may be cut in at once and the engine brought up to the required speed. The cutting in of the fuel is accomplished simply and easily by means of the governor or hand-lever control already referred to, acting on the spill valve. This valve may be so set that all the oil pumped by the fuel pump is spilled—none going to the fuel valve; or again it may be so set that all the oil pumped is sent to the fuel valve, and none spilled. Between these limits any setting of the spill valve may be obtained to suit the load being carried by the engine.

(To be continued.)

CATALOGUES.

Electric Cables.—A catalogue containing illustrations of sections of a variety of their cables has come to hand from the Macintosh Cable Company, Limited, Rice-lane, Walton, Liverpool.

Water Meters.—A series of six meters for trunk mains, districts and sub-districts, trade supplies, mixed and domestic supplies and general use are illustrated in a small catalogue received from Messrs. George Kent, Limited, 201, High Holborn, London, W.C.

Concrete Reinforcement.—Concrete reinforcements, composed of square wires and woven mesh suitable for stirrups and links, pile frames, posts and lintels, roads, floor slabs and general work, are dealt with in a 50-page catalogue received from Messrs. Brown and Tawse, Limited, 3, London Wall Buildings, London, E.C. 2. Elaborate tables of loads for floors are also included.

Electric Motors.—Lists to hand from Messrs. Wright Motors, Limited, Halifax, deal with two and three-phase induction motors of the protected, ventilated, totally enclosed, pipe ventilated, and rainproof, types, as well as crane-rated slip-ring and single-phase squirrel-cage and slip-ring induction motors. Specifications, prices and the usual technical and commercial particulars are given in compact tables for each type.

Cranes.—Overhead travelling cranes generally of 5 tons to 20 tons lifting capacity, but including examples with lifting capacities of from 3 tons to 60 tons, are shown by a series of illustrations in a catalogue received from Messrs. John M. Henderson and Co., Aberdeen. The cranes are all electrically driven with various control systems and special lifting tackle for particular purposes. The text of the catalogue is printed in French, Italian and Spanish, as well as in English.

Electric Locomotives.—Various types of electric locomotive for ordinary rail traction with light and heavy loads, for shunting and yard work, as well as for use in mines, quarries and other special places, are illustrated and described in a catalogue received from the Sanderson, Bibby Company, Limited, 36, Kingsway, London, W.C. 2. The list is especially informative as to the special conditions in which the electric locomotive can be employed with advantage for reasons of safety, convenience or economy.

Chimney Losses.—We have received from the Uehling Instrument Company, of Paterson, N.J., U.S.A., pamphlets on the magnitude of the "Power Plant Chimney Losses," and on the "Relation between CO_2 and Money wasted up the Chimney." In the latter pamphlet a series of formulæ are given for determining from the percentage of CO_2 in the flue gases the amount of heat wasted up the chimney. For bituminous coal the formula is: Per cent. of heat wasted

$$= 4{\cdot}05 + \frac{162{\cdot}3}{\text{Per cent. } CO_2}.$$

Mechanical Stokers.—A series of six consecutive boiler trials were carried out in the latter part of last year by the staff of the Bristol Corporation Electricity Works to test the economy of different coals fired in the same boiler, using the same furnace and mechanical stoker in each case. The fuel used was small coal from Glamorganshire and Monmouthshire, Gloucestershire slack, anthracite grains and coke breeze, and the trials were generally carried on for 6 hours at full load, with an additional hour at overload in some cases. The boiler was of the water-tube type, by Messrs. John Thompson, Wolverhampton, and the stoker was by the Underfeed Stoker Company, Limited, Coventry House, South place, London, E.C. 2. The latter company has recently published a pamphlet giving the results of the trials in full, and the figures given will be of exceptional interest to engineers in charge of boiler plant.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

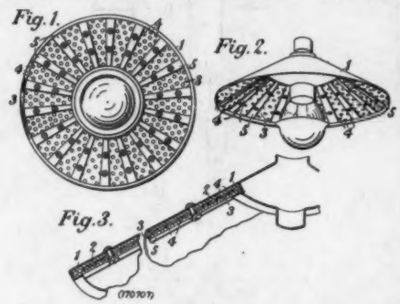
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

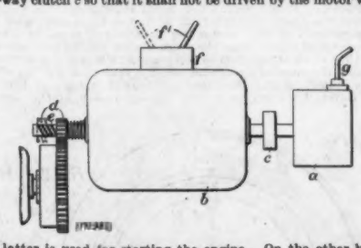
ELECTRICAL APPARATUS.

170,707. J. D. Turing, London, and The Sheringham Daylight, Limited, London. Reflectors. (3 *Figs.*) August 12, 1920.—The invention relates to reflectors for use in the production of artificial daylight. According to the invention, the reflecting surface of the reflector is built up of a number of superposed layers of material, or partial layers, each layer or partial layer being coloured with one of the several colours to be used. The layers of material are so superposed as to expose parts of the lower layers, so that when the reflector is completed the correct proportional areas of the various colours are exposed. The drawings show a reflector employing three or four colours. The inner surface of a conical shade 1 is covered with a layer 2



of material coloured with one of the colours. Over the first layer is placed a second layer 3 of material coloured with another of the colours and perforated uniformly with circular holes 4. Upon this second layer are fixed radial strips 5 coloured with the third colour. Conveniently the radial strips 5 may be employed to hold the perforated layer 3 in position, and the three layers may be secured together and to the shade 1 by means of bolts passed through the radial strips, the heads or nuts of the bolts being coloured with any of the colours previously employed, or with a fourth colour. Additional square or shaped patches of material coloured with the fourth colour may also be provided on the radial strips if desired. (*Sealed.*)

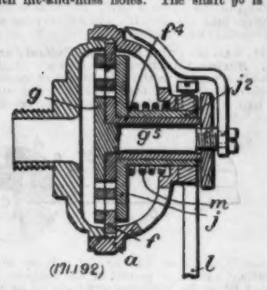
170,989. C. A. Vandervell, Acton Vale, and C. A. Vandervell and Co., Limited, Acton Vale. Electrically-Driven Air Compressors. (1 *Fig.*) August 24, 1920.—According to this invention, use is made of the starting motor ordinarily employed for starting the internal combustion engine of a motor car for driving an air compressor, the latter being more particularly intended for filling the tyres. In carrying the invention into effect, use is preferably made of an electric starting motor of the kind having a pinion travelling on a screw thread and engaging with a toothed member provided on the flywheel. The air compressor *a* is connected to the starting motor *b* through a one-way clutch *c* so that it shall not be driven by the motor when



the latter is used for starting the engine. On the other hand, in order to prevent the pinion *d* advancing on the screw-thread *e* when the motor is used for driving the compressor, the direction of rotation of the motor in the latter case is reversed, such as by means of a change-over switch *f*. When the switch handle *f*1 is in the position shown in full lines, the motor *b* rotates in one direction and is used for starting; in this case the compressor *a* remains stationary. When the switch *f*1 is in the position shown in dotted lines, the motor rotates in the opposite direction, and the pinion *d* remains in the position shown in dotted lines; in this case the compressor *a* is driven by the motor through the free-wheel clutch *c* and compressed air can be delivered through a pipe *g* for filling the tyres. (*Sealed.*)

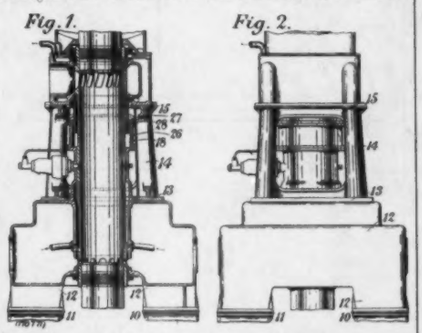
GAS ENGINES, PRODUCERS, HOLDERS, &c.

171,192. A. Griffiths, Bexley Heath, Kent. Internal-Combustion Engines. (11 *Figs.*) August 17, 1920.—The invention relates to a valve to admit additional air into the induction pipe of an internal-combustion engine under control of the accelerator gear. The invention further relates to a hit and miss type of valve, and provides a construction in which the discs *f*, *g* and the shutter *j* are enclosed within a protective casing *a* divided into two compartments by the disc *f*, and in which the adjustable disc *g* by which the effective sizes of the perforations are determined is arranged for hand manipulation from outside the casing, and for fixing after setting. The casing *a* is a two-part one, and the fixed disc *f* divides it off into two interior compartments, the disc having as part of it a sleeve member *f*4 extending to the exterior of the casing. The disc *g* works against the one face of the disc *f* and is formed with a short length shaft *g*5 passing through the sleeve *f*4 to the exterior. The shutter *j* works against the other face of the disc *f* and has a sleeve *j*2 revolving upon the sleeve *f*4. An arm *l* of the accelerator gear connects with the sleeve *j*2. The discs *f*, *g* are similarly perforated with hit-and-miss holes. The shaft *g*5 is arranged



for hand operation outside the casing *a* to set the holes of the disc *g* to the holes of the disc *f* for adjusting the effective sizes of the perforations, which adjustment can afterwards be locked by a locking nut engaging the exterior of the shaft and screwing up against an end abutment of the sleeve *f*4. A spring *m* may be provided to make the action of the shutter airtight to the disc. (*Sealed.*)

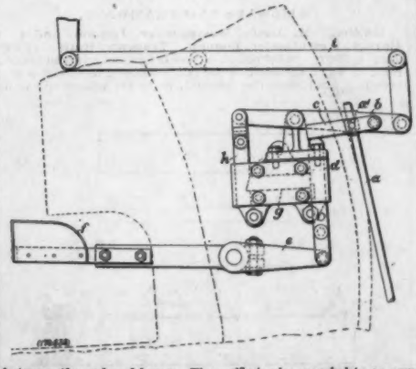
170,771. R. P. Doxford, Sunderland, and K. O. Keller, Sunderland. Internal-Combustion Engines. (2 *Figs.*) November 6, 1920.—In an opposed-piston internal combustion engine having a double-ended cylinder supported at its middle, in relation to which both of its ends are free to expand and contract, by a water jacket casing that is mounted on the engine-frame and takes the weight of the cylinder, there is employed, according to this invention, an entablature that comprises a base 13 which rests upon the bridge-piece 12 and columns 14 which terminate at their upper ends in a platform 15, and is characterised in this, that it is distinct from the water jacket 26, 27, is mounted on the engine frame 10, 11, 12, and is in sliding connection with the cylinder 18 and jacket 26, 27, so that not



only does it not take the weight of the cylinder, but it diverts through itself away from the jacket and cylinder to the standing lower portion of the engine structure the lateral stresses that otherwise would travel down to the said lower portion by way of the lower parts of the cylinder and jacket. The parts are so constructed that the water jacket casing is in two portions, an upper 27 and a lower 26, that there can be relative movement between these two portions, that a packing device 28 constituting a sliding joint between the bottom of the upper portion 27 and the top of the lower portion 26 is provided, and that the entablature 13, 14, 15 is of skeleton form to permit access to the packing device 28 and to any other parts or devices used on the cylinder or jacket. (*Sealed.*)

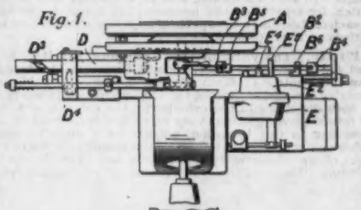
MACHINE AND OTHER TOOLS, SHAFTING, &c.

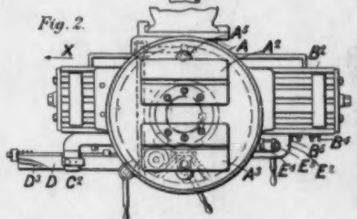
170,638. E. Day, Wakefield. Power Presses. (1 *Fig.*) July 19, 1920.—This invention relates to a guard for power presses of the type which is so characterised that only the weight of the guard itself bears upon the fingers of the operator, should they be in the way. The treadle is coupled through a rod *a* to a horizontal lever *b*, a pin-and-slot connection *a*1 being provided

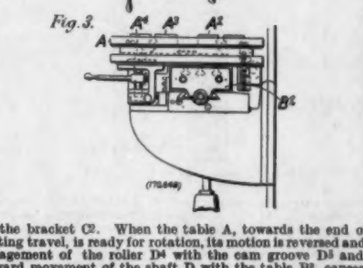


between the rod and lever. The rod *a* is also coupled to an arm *c* pivoted to the lever *b*, and in the primary part of its movement the rod *a* raises the arm *c* without imparting movement to the lever *b* by which it is carried. The arm *c* rests upon a vertical slide *d* coupled by a link *e* to the pivoted guard *f*. The horizontal sliding key *g* engages within a notch in the slide *d* when the latter is sufficiently elevated to provide that the guard *f* is in its final and precise position. This key *g* has at its end remote from the slide *d* an inclined surface which co-operates with an inclined surface provided upon a second slide *h* linked to the horizontal lever *b*. When, therefore, in the continued movement of the treadle, the lever *b* is displaced, the key *g* is forced into the notch in the slide *d*, thereby locking the latter in the position for retaining the guard *f* in its protecting position. The lever *b* is linked to a lever *i*, coupled to the clutch, so that after the guard *f* has been thus locked the continued movement of the treadle effects the engagement of the clutch. (*Sealed.*)

170,648. Sir A. Herbert, Whitchurch, and P. V. Vernon, Keresly, near Coventry. Milling Machines. (5 *Figs.*) July 22, 1920.—This invention relates to work tables, and work-chucking devices for milling machines. According to this invention, the rotatable work table is adapted to be rotated automatically during the longitudinal travel of the main slide after conclusion of an operation on a piece of work, and while the slide is returning to its initial position for the commencement of a fresh machining operation. A rotatable horizontal circular table A is mounted upon the work table B2 and is provided with two work-chucking devices A^2, A^3, located 180 deg. apart, with automatically-operating indexing means (comprising recesses A4 below the table and a bolt A^5 to engage them in turn) for locating the table in the two corresponding positions to bring the chucking devices, and thus the work, successively into position adjacent the cutting tool (not shown). Rotation of the table A is effected through intermediate gearing by a shaft D extending in the direction of movement of the table B^2. This shaft is formed with a cam groove D^3, which is engaged by a roller D^4 mounted







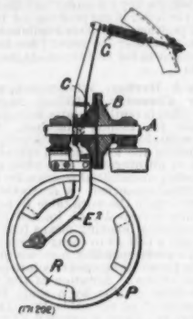
on the bracket C^2. When the table A, towards the end of its cutting travel, is ready for rotation, its motion is reversed and the engagement of the roller D^4 with the cam groove D^3 and the onward movement of the shaft D with the table B^2, causes the rotation of the shaft D, and thus through the intermediate gearing the rotation of the table A. For the feed movements of the table B^2, the milling machine carries a feed box E for producing automatically the requisite changes of feed, and a trip box E^2 with gear-tripping members adapted to be engaged in their order by dogs or fingers B^3, B^6 secured to the sides of the table B^2 and positionally adjustable thereon so that at the limits of travel the outer ones B^3, B^4 effect the reversals of the table, while another B5 brings the quick travel gear into action and the last one B^6 engages the feed gear. These several gears in the feed-box are adapted, when the table commences its working travel in the direction of the arrow X (Fig. 2), to bring the work rapidly to the cutting tool, then to change the speed to the appropriate rate and after the cutting operation is complete, to increase again the speed to take the work clear of the cutter. (*Sealed.*)

170,789. The Howard Pneumatic Engineering Company, Limited, Eastbourne, and W. M. S. Wyld, Eastbourne. Transmitting Rotary Motion. (2 *Figs.*) January 25, 1921.—For transmitting the rotary motion of a crankshaft to a pinion, the pinion is provided, according to this invention, with a projection which fits over the end of the crankshaft web. 1 is a

crankshaft having a web 2 and a crank-pin 3. Mounted on the crankshaft 1 is pinion 4 having a projection 5 which fits over and forms a driving or driven connection with the crank web 2. With this arrangement the crankshaft 1 may be made of less diameter (to withstand a given strain) than is the case when the drive is transmitted in the usual manner. (*Sealed.*)

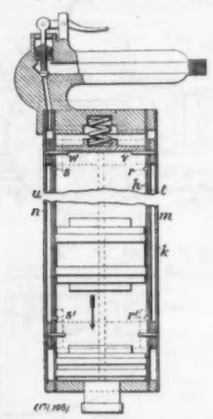
171,202. J. G. Jackson, Limited, Pollokshaws, Glasgow, and J. G. Jackson, Pollokshaws, Glasgow. Friction Clutch Driving Mechanism. (2 *Figs.*) August 20, 1920.—According to this invention, the driving and driven members B, C, respectively, of the friction clutch are of disc character and provision is made whereby these members are permanently acted on by a force which tends to bring them into driving connection associated with cam mechanism which operates to

disconnect intermittently the clutch. The force applied tending to produce connection is derived from a spring G, the strength of which may be varied, and the cam mechanism comprises a disc P rotated from the driving shaft A, having one or more cams R



adapted to act on a rocking arm E², connected with the friction clutch, for separating the members. If required, the cams R, or each of them, may be capable of adjustment to produce varying periods of rest. (*Sealed.*)

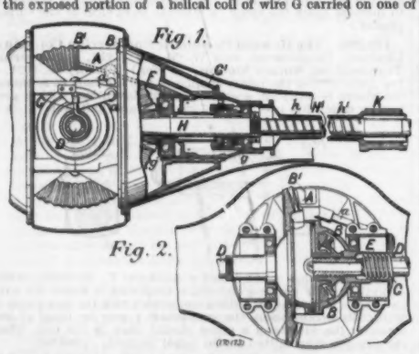
171,146. The Vacuum Tool Company, Limited, London, and G. J. Gawley, Fleet. Fluid Pressure-Operated Percussive Tools. (3 *Figs.*) August 3, 1920.—In fluid pressure-operated percussive tools of the kind wherein a piston is moved in both directions in the cylinder by the creation of a vacuum or reduced pressure alternately on each side thereof, the piston, according to this invention, automatically operates valves at either end of the stroke to control the communication of the two sides of the piston with the pressure and source of suction or vacuum. The working cylinder A is advantageously provided



with an outer concentric casing *k*, divided longitudinally into two compartments *m*, *n*, arranged in connection with the pressure and a source of suction or vacuum, respectively. A pair of ports *r*, *s* is provided at one end of the cylinder and a similar pair r^1, s^1 at the other end. The ports *r*, r^1 are in connection with the pressure compartment *m* and the ports *s*, s^1 with the vacuum compartment *n*. A pair of slide valves *t*, *u* is arranged to control the ports, the valves having fingers or tappets *v*, *w* thereon, with which the piston *a*, at the ends of its strokes, makes contact to operate the valves. (*Sealed.*)

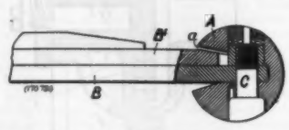
MOTOR ROAD VEHICLES.

170,173. O. D. Cars, Limited, Belfast, and F. S. Eves, Belfast. Motor Road Vehicles. (2 *Figs.*) August 25, 1920.—This invention relates to the lubrication of the differential gearing and bearings of motor road vehicles. According to this invention, a scoop or trough A is fitted in the casing B carrying the bevel gear unit. Oil is flung into this trough by the teeth of the revolving crown wheel B^1 and is led by a pipe *a* to the exposed portion of a helical coil of wire G carried on one of



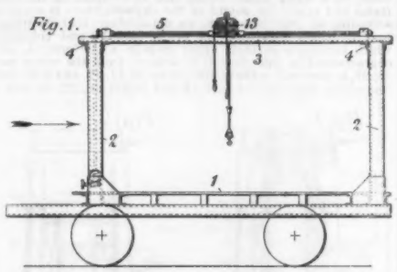
the axle shafts D near the point where it enters the differential housing B. The wire coil G is surrounded for the greater portion of its length by a sleeve E and is anchored to a fixed part. The direction or hand of the wire helix G is such that when the car is moving forward the frictional drag of the oil forces it to travel towards the centre of the differential housing B, passages being provided to conduct the oil to the various bearing surfaces in the differential gear mechanism. A second passage F leads the surplus oil from the scoop A to the interior of the bevel pinion housing G^1 where it lubricates the ball bearings *g* supporting the bevel pinion shaft H. Should it be required to lubricate the intermediate bearing K in the torque tube, the oil is caused to come into contact with a wire helix A on the propeller shaft H^1 as it leaves the bevel pinion housing G^1. A tube A^1 surrounds the propeller shaft H^1 between the intermediate bearing K and the forward end of the housing G^1. The wire helix A is affixed to and revolves with the shaft H^1, and conveys the oil to the intermediate bearing K. (*Sealed.*)

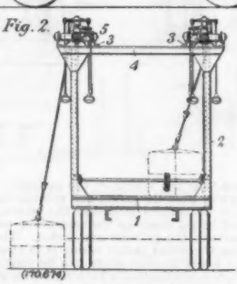
170,731. O. D. Cars, Limited, Belfast, and F. S. Eves, Belfast. Spring Attachments. (1 *Fig.*) August 25, 1920.—This invention relates to the attachment of springs of the cantilever type to the axle of road vehicles. The attachment comprises a ball A with a horizontal slot *a* to receive the end of the



master leaf B^1 of the spring, the slot *a* being bevelled or flared to a sufficient extent to permit of the entry of the end of the second leaf B^1 of the spring to or nearly to or over the centre of the ball A. A bolt C is passed vertically through the ball and through a hole in the master leaf B. The ball A is held in position by two cups secured to the axle. (*Sealed.*)

170,674. E. M. Munro, London. Loading and Unloading Motor Vehicles. (7 *Figs.*) July 27, 1920.—This invention has for its object the provision on motor road vehicles of means whereby the loading or placing of the merchandise thereon may be effected more easily and in quicker manner than is now the case. The invention comprises, in a motor propelled road vehicle, the combination with the vehicle platform, of a framework mounted thereon, a shaft rotatably mounted in said framework, a winch mounted on the shaft, and means for driving the shaft





from a propelling motor. In carrying out one part of the invention, there is mounted at each corner of the platform 1 of a motor road vehicle, a standard 2. The four standards 2 are connected together at their upper ends by horizontal members 3 parallel with the sides of the platform 1 and by horizontal members 4 parallel with the ends of the platform 1. There is thus constituted on the platform 1 a rectangular framework. 5, 5 are horizontal shafts mounted on the rectangular framework. Each shaft 5 is geared to a propelling motor which may be that of the vehicle. The shafts 5 thus rotate simultaneously and each carries a winch 13, which can be traversed from end to end thereof. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

168,664. E. Jacob, Westminster, London, and C. D. Burnet, Westminster, London. Tramway Rails. (7 *Figs.*) June 4, 1920.—In fishplates, for use in forming joints in tramway rails, in which the head of the rail is recessed to receive a corresponding head upon the fishplate, parts are welded to the fish-

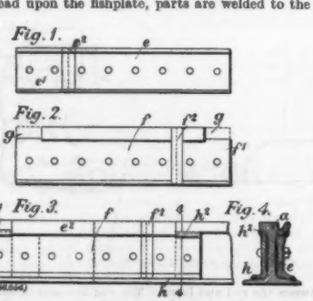
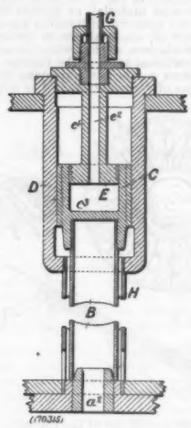


plate to permit the extension of the web portion thereof beyond the head, the welded seams not being in line with the weak parts of the rails where the section is reduced. In carrying the invention into effect, the fishplate *e* (Fig. 1) for use on the check side of the rail is lengthened by means of a short length e^1, which is welded to the plate *e* at e^2. The fishplate *f* (Fig. 2) which is used on the head side of the rail is lengthened by the addition of a short length f^1 of similar cross-section, which is welded thereto at f^2. The head portion of the fishplate thus lengthened is cut away at each extremity as indicated at *g*. When the fishplates *e* and *f* are fitted in position with reference to the joint in the rails, as shown in Fig. 3, the welded joints of these two fishplates are disposed at different positions, and also do not coincide with the points where the rails are weakest, or where the ends thereof meet. The fishplates are welded to the rails as indicated at A, A^1 and A^2, the welds at A^1 and A^2 serving to strengthen the rails at their weakest points. (*Sealed.*)

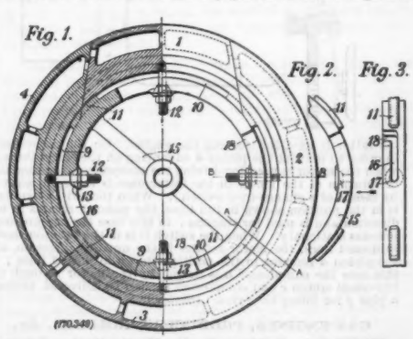
170,315. G. C. Bailey, Hoole, Chester. Sanding Apparatus. (3 *Figs.*) May 13, 1920.—According to the invention, the valve which controls the sand outlet at the bottom of the sand-containing box is of tubular configuration, and its lower annular face fits a corresponding annular valve seating co-axial with and surrounding the sand outlet opening a^2. The valve and its spindle take the form of a cylinder or tube B, the lower open end of which forms the annular valve face; the tube B is directly connected to valve operating means arranged vertically in line with it, which means comprise a fixed piston E adapted to fit and close the open upper end of the bore of a cylindrical recess c^5 formed at the top of the tube B; the cylindrical recess may be formed in the bore of the tube B, but preferably it is formed in a cylindrical sleeve C secured to the tube and capable of axial movement with the tube B relatively to the piston E. The



cylindrical recess c^5 communicates through a bore c^2 passing through the fixed piston E and piston rod c^1 to a connecting pipe G which is led to a control valve by means of which the recess c^5 can be connected to either of two sources having different pneumatic pressures, say, to a vacuum pipe, such as the vacuum pipe of the brake-operating gear of a locomotive, or to the atmosphere; when the recess c^5 is connected to the vacuum pipe the unbalanced upward pressure of the atmosphere on the moving part opens the valve; when the recess c^5 is connected to the atmosphere the pressure on the moving part is balanced and the valve is closed by gravity, assisted if necessary by a spring. The tube B is protected by a fixed tube H, the lower end of which is held in position concentric with tube B, and the upper end of which is screwed into the open lower end of a casing D, which is fixed to the top of the sand box. (*Accepted October* 19, 1921.)

MISCELLANEOUS.

170,349. Wood-Milne, Limited, Westminster, London, E. R. Pearce, Leyland, and R. Tooley, Leyland. Moulds for Pneumatic Tyre Covers. (5 *Figs.*) July 12, 1920.—This invention relates to moulds for use in making pneumatic tyre covers. The annular segmental core proper comprises four segments 1, 2, 3, 4, the cross-section of which corresponds to the pneumatic tyre cover required, and the diameter of which when the segments are assembled corresponds to that of the tyre cover it is designed to make. Adapted to fit within the annular segmental core is a spider 15, the rim of which has projecting therefrom four key lugs 11, spaced 90 deg. apart, of dovetail section to fit the key grooves 9 of the segments.



Between the key lugs the spider rim is formed with four slots 16, each terminating at one end in a conical recess 17 corresponding to conical washers 13, and at the other end each slot 16 communicates with a lateral opening 18 through which the stud 12 on the corresponding segment can pass, the relation of the lateral openings 18 to the slots 10 in the segments communicating with the key grooves 9 being such that when the spider 15 is placed within the annular segmental core with the studs 12 in position to enter the lateral openings 18, the key lugs 11 on the spider are in line with the segment slots 10, so that the spider 15 is free to drop down in position within the segmental annular core when, by relative rotary movement, the parts can be engaged and locked in position. (*Sealed.*)